

THE GRADUATE SCHOOL *catalog*

1962-1964

Wm. J. Austin

State College Record

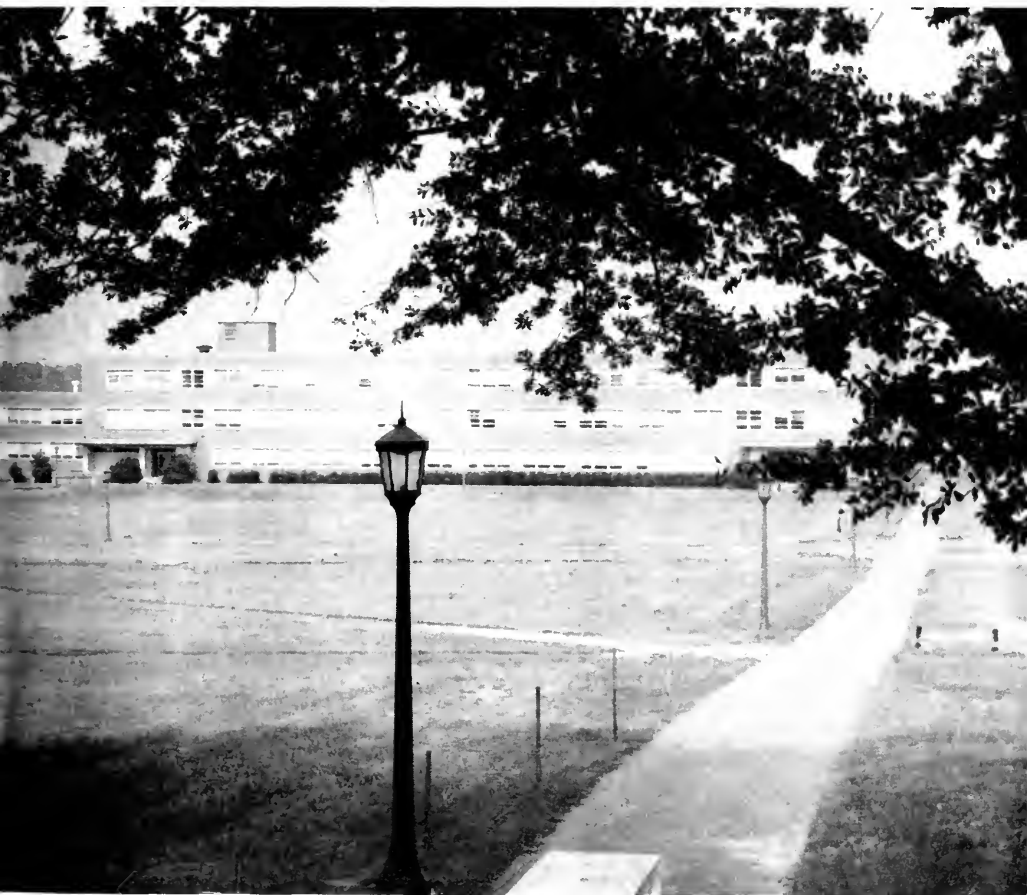
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This issue of The Graduate School Catalog is one in a series of publications being published during North Carolina State College's Diamond Jubilee and the Centennial of America's unique Land-Grant Colleges and Universities. Joining North Carolina State College in the national celebration of the Centennial are the 67 other Land-Grant Colleges and Universities in the United States. It was a century ago on July 2, 1862, President Abraham Lincoln signed the Morrill Act establishing the Land Grant system of public higher education.



Gardner Hall houses the offices of the Graduate School Dean.

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THE COLLEGE

North Carolina State College officially began its operations on October 3, 1889, with 45 students matriculating. The 1961 fall semester student body enrollment numbered more than 7,000 with a teaching staff of 660 and a total staff of nearly 3,000, including administrative, extension, and research personnel across the State.

Keeping pace with the College's growing enrollment is the expanding physical plant. State College's initial physical plant would be dwarfed if it could be placed side by side the well planned and constructed plant of today which is valued at more than \$50 million and includes 72 major buildings.

In the late 1880's when the College was still a toddler taking its first steps up the academic ladder, the campus was made up of one building (which is still standing), one stable, two mules, one horse, and a 60-acre farm. Now State College has reached the top of the ladder in the fields of science and technology and can justly boast of its equally superior physical plant.

Among the newest buildings on campus is Harrelson Hall, a circular classroom building seating 3,500 students at a time in classes ranging in size from 18 to 189. The colossal structure was built at a cost of \$2,500,000.

Another new addition to the growing State College campus is the William D. Carmichael Gymnasium, one of the nation's most modern structures of its kind, valued at \$2,600,000.

State College, always looking forward to tomorrow and its apparently never ceasing growth, is preparing its campus to accommodate the influx of students anticipated during the approaching years.

The College is constructing horticultural and plant pathology greenhouses totaling \$100,000 in cost and extension to its utilities which is costing \$900,000. In addition, several construction projects, totaling \$7,635,000 in cost, are being designed.

Unique Harrelson Hall is the home of seven College departments.





Holladay Hall is the oldest building on the State College campus.

North Carolina State College owns 3,500 acres of land, including 650 in the Raleigh campus and 2,850 in orchards and farms. In addition, it has access to 97,000 acres of woodlands used as outdoor forestry laboratories.

Looking back through the well written chapters of the North Carolina State College history book, page one reveals that one of the State's most far-sighted citizens, Colonel Leonidas L. Polk, editor of *The Progressive Farmer*, and the Watauga Club, an association of industrious young Raleigh men, were guiding lights in the College's beginning.

The Watauga Club proposed an industrial school "to add the products of the mines, forests, and factories to agriculture, so that the people will no longer be dependent on the North for technical experts and manufactured articles of daily use."

Colonel Polk campaigned for a new college under the provisions of the Morrill Land-Grant Act of 1862, through which Congress donated public land or its equivalent in land scrip for the creation of an agricultural college in each state.

For several years the land scrip fund in North Carolina had gone to the University of North Carolina at Chapel Hill, but Polk contended that only the creation of a specialized technical institution would fulfill the true Land-Grant purpose.

R. Stanhope Pullen, one of Raleigh's leading citizens, offered 50 acres of land for the new college. A new bill-transferring the Land-Scrip Fund from the University of North Carolina and accepting Pullen's offer was passed by the Legislature and ratified into law on March 7, 1887, to form the North Carolina College of Agriculture and Mechanic Arts.

Much later in 1931, the General Assembly formed the Consolidated University of North Carolina, taking in the University at Chapel Hill, State College at Raleigh, and the Woman's College at Greensboro.

THE GRADUATE SCHOOL OF THE UNIVERSITY OF NORTH CAROLINA

STATE COLLEGE DIVISION

DONALD B. ANDERSON, *Vice President, Graduate Studies and Research, Chapel Hill*

WALTER JOHN PETERSON, *Dean, Raleigh*

The Graduate School of the Consolidated University of North Carolina is composed of three divisions, one at each of the three units of the University System. Each branch of the Consolidated Graduate School is administered by a graduate dean who works in close association with the vice president in charge of Graduate Studies and Research. The Graduate Council is composed of representatives of the Administrative Boards of each of the three units of the Consolidated University. At State College the graduate dean is assisted in all matters of policy by an Administrative Board of ten members. Seven are elected by the faculties of the degree-granting schools and three are appointed by the chancellor after consultation with the dean.

Graduate instruction at State College is organized to provide opportunity and facilities for advanced study and research in the fields of agriculture, engineering, forestry, physical sciences and applied mathematics, technological education, and textiles. The purpose of these graduate programs is to develop in advanced students a more adequate comprehension of the scope of knowledge in these special fields of learning and an understanding of the requirements and responsibilities essential for independent research investigations. In all of the graduate programs emphasis is placed upon a high level of scholarship rather than upon the satisfaction of specific course or credit requirements.

The full resources of the Consolidated University of North Carolina are available to all graduate students enrolled at any one of the three branches of the Graduate School. Exceptional facilities for graduate study are provided at State College. New buildings furnish modern well equipped laboratories for graduate study in specialized areas of agriculture, engineering, forestry, physical sciences and applied mathematics, and textiles.

The North Carolina Agricultural Experiment Station and the Department of Engineering Research are integral parts of the College. The staff, research facilities, equipment, and field studies of these organizations contribute in a very important way to the graduate programs of the College. The Institute of Statistics on the State College campus makes available to graduate students unusual opportunities in this important phase of research study.

The State of North Carolina, extending from the Atlantic Ocean westward about 500 miles to the Appalachian Mountains, possesses an exceptional range of climatic and topographic environments. The Coastal Plain, the Piedmont, and the mountains provide a rich pattern of agricultural and industrial activities which offer unusual opportunities for research study and employment.

State College is located in Raleigh, situated on the boundary separating the broad coastal plains on the East from the rolling terrain of the Piedmont on the West, about midway between the northern and southern boundaries of the State. Raleigh is 29 miles from Chapel Hill, the location of the University of North Carolina, and 26 miles from Durham, the home of

Duke University. The libraries and other facilities of the three institutions make this area one of the important centers of research opportunity in the South.

College Library

The North Carolina State College Library has excellent holdings in materials essential for research study in the graduate curricula offered by the College.

As of July 1, 1961, the College Library held more than 227,000 volumes of books and bound journals, and more than 12,000 bound volumes of documents. The books and journals have been selected to reflect strongly the scientific and technological interests of the College, and the documents represent a most important increment of the whole collection. They include, in addition to the publications of the Federal government, all publications of the various Agricultural Experiment Stations, most of the publications of the Engineering Experiment and Engineering Research Stations, and publications of the various research stations from all over the world.

The depository status of the College Library may be described as follows:

1. The Library is a complete depository for all unclassified publications of the Federal government that are available for distribution. This includes publications of the USDA, Geological Survey, National Bureau of Standards, Department of Interior, etc. Since 1923, the year the Library was designated as a depository, its document holdings in the fields of State College's special interest are almost 100 per cent complete.
2. The Library is a "selective" depository for the publications of the Carnegie Institution of Washington and has excellent files of these valuable monographs.
3. The Library is a depository for all unclassified and declassified publications of the Atomic Energy Commission.
4. The Library receives on exchange the publications of many foreign countries—especially publications dealing with the agricultural sciences and with engineering.
5. In July, 1960, the Library became a full depository for the publications of the Food and Agriculture Administration of the United Nations.

In July, 1959, the Library acquired the Tippmann Collection of Entomology, the outstanding private collection of Dr. Friedrich F. Tippmann of Vienna. This collection contains 6,200 rare books and bound research journals in the field of entomology.

The Library's research holdings are particularly strong in the fields of entomology, nuclear energy, genetics, aeronautics and space technology, engineering, and physics, and include files of the major journals in these fields. A large and useful collection of books in the humanities and the social sciences is available for the use of undergraduates.

The Textiles Library located in Nelson Textile Building contains outstanding holdings in textiles and textile chemistry, and the School of Design Library in Brooks Hall has a top-level collection of books, journals and slides in the fields of architecture, landscape architecture, and product design.

The resources of the College Library together with the inter-library loan service available from other neighboring scientific libraries make it a highly satisfactory adjunct of the graduate program of the College.

A reciprocal arrangement has been made with the Library at the University of North Carolina and the Duke University Library whereby their

facilities are available to the State College faculty and graduate students who may wish to deal with these libraries directly.

Identification certificates enabling participation in this reciprocal arrangement may be secured at the office of the director of the State College Library.

Institute of Statistics

The Institute of Statistics is composed of two sections, one at State College and the other at Chapel Hill. At State College, the Institute provides statistical consulting services to all branches of the institution, sponsors research in statistical theory and methodology, and coordinates the teaching of statistics at the undergraduate and graduate level. The actual instructional and other academic functions are performed by the Department of Experimental Statistics, which forms a part of the Institute.

The purpose of the Institute is to provide extra depth and strength in the development and use of modern statistical procedures throughout the Institution. This involves cooperative efforts with many schools, departments, and agencies. The establishment of a nationally recognized program in quantitative genetics and recent developments in the field of biomathematics illustrates the coordinating role the Institute plays in the quantitative sciences.

In addition to these local activities, the Institute maintains close and continuing contact with statistics scholars, research programs, and graduate instruction programs throughout the world. It has helped develop an international abstracting journal for statistical articles. The Institute is the point of contact for grants and contracts in statistics. It has been active in organizing and maintaining a strong Southern Regional Cooperative Graduate Summer Session in statistics. Approximately fifteen graduate assistantships in statistics are made available annually through the efforts of the Institute. All of these contributions have added substantially to the vigor of the entire graduate program of State College.

Computing Facilities

A number of high speed computing facilities are available for graduate instruction and research.

An IBM 650 digital computer is located in the Computing Center, Patterson Hall, and is available for graduate student research. It is also used in connection with credit courses and non-credit short courses in computer programming and operation. It is supplemented by a number of other IBM machines. The IBM 650 will be replaced in 1963 with an IBM 1410.

Several other computers are available for use by graduate students. A GEDA (Goodyear Electronic Differential Analyzer) is in use in the Mathematics Department's research and graduate instruction program, particularly used in problems involving large scale linear and non-linear differential equations. Several Donner analog computers are used on the campus for classroom instruction and research projects. A UNIVAC (Remington Rand 1105) is in operation at the University at Chapel Hill and is also available for faculty and graduate student research.

Nuclear Reactor Project

The Nuclear Reactor Project at State College constitutes one of the most advanced and complete university reactor laboratory facilities in the country.

A 100 kilowatt tank-type heterogeneous reactor and a 100 watt homogeneous reactor are available for graduate research and laboratory study. Aimed principally toward graduate work in nuclear science and engineering, the Project includes laboratory classrooms in addition to several research laboratories. Facilities are also available for studies in radiochemistry, nuclear electronics, health physics, and solid state physics.

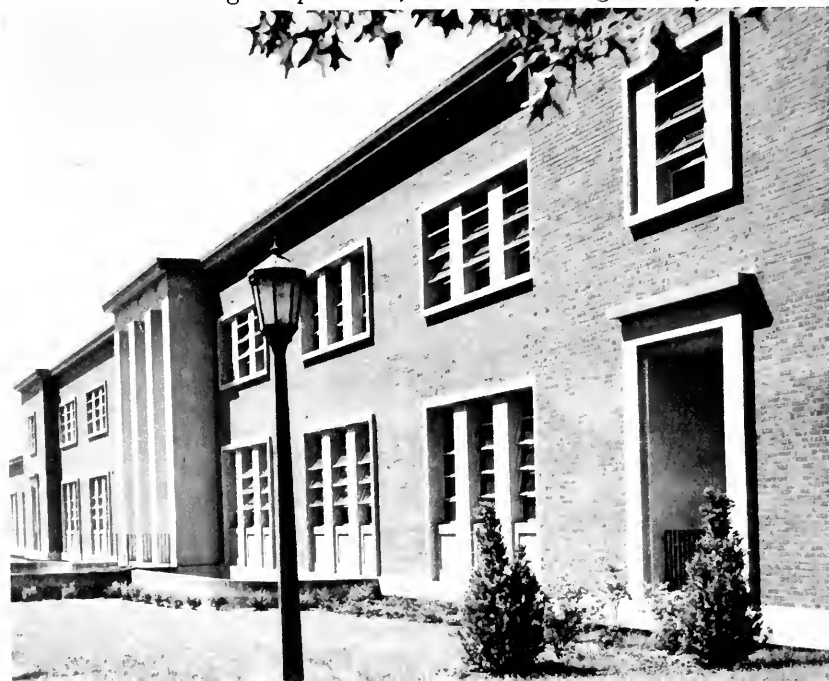
The Project has a wide variety of associated research equipment including numerous items of nuclear electronics, a neutron diffraction spectrometer, a 200 channel pulse height analyzer-scaler, and time-of-flight instrumentation.

Student, faculty, and contract research activities are concurrent with the instructional programs, which produce an atmosphere that is stimulating to the student and helps keep classroom teaching abreast of recent developments in nuclear science.

Research Program at the Oak Ridge Institute of Nuclear Studies

North Carolina State College as a unit of the Consolidated University of North Carolina is one of the sponsoring institutions of the Oak Ridge Institute of Nuclear Studies located at Oak Ridge, Tennessee. Through this cooperative association with the Institute, State College's graduate research program has at its disposal the facilities and research staff of Oak Ridge National Laboratory. An extensive research program is underway there on the physical and biological effects of radiations, uses of radioisotopes and many other nuclear physics and chemical processes. When master's and doctoral candidates have completed their resident work, it may be possible, by special arrangement, for them to go to Oak Ridge to do their research problems and prepare their theses. In addition, it is possible for the staff members of this University to go to Oak Ridge for varying periods, usually not less than three months, for advanced study in their particular fields.

N. C. State College is proud of its outstanding library facilities.



ADMISSION

Graduate School admission may be to full graduate standing, provisional or unclassified status. Applications for admission to the Graduate School must be accompanied by official transcripts from all colleges previously attended.

Full Graduate Standing.—For admission in this category a student must have a bachelor's degree from a recognized college or university regarded as standard by a regional or general accrediting agency and at least a B grade average in his undergraduate major.

Provisional admission may be granted to applicants who lack undergraduate work considered essential for graduate study in the major field. Course work, without graduate credit, will be required to make up such deficiencies before admission to full graduate status can be granted.

Graduates from non-accredited institutions may be granted provisional admission when their academic records warrant this status. Additional course work will be required of such students when deficiencies in their previous training are apparent.

Graduates from accredited institutions whose scholastic records are below the standards for admission to full graduate standing may be admitted provisionally when unavoidable extenuating circumstances affected their undergraduate averages or when progressive improvements in their undergraduate programs warrant provisional admission. All such students are required to take the Graduate Record Examinations and to submit scores to the Graduate Office in support of their application. The National Teacher's Examination may be substituted for the Graduate Record Examination if recommended by the department head. Information as to the dates on which the Graduate Record and the National Teacher's Examinations are given may be obtained at the Graduate Office.

Graduate students admitted on a provisional status may attain full graduate standing when the deficiencies responsible for their provisional status are corrected. They also must have maintained a satisfactory academic record in all course work taken as part of their graduate program. Change from provisional to full graduate standing is effected only on written recommendation from the department in which the student is seeking his degree.

Unclassified graduate students are not candidates for graduate degrees. They may take courses for graduate credit, but may not apply more than ten credits earned while in the unclassified status to any program leading to an advanced degree at this institution. Unclassified graduate students are expected to meet the same admission requirements that apply to graduate students in full standing.

Applications for admission to the Graduate School should be on file in the Graduate Office at least thirty days in advance of the registration date for the term in which the student wishes to enroll in the Graduate School.

Students who apply for admission to the Graduate School without having allowed sufficient time for the study of completed transcripts, or prior to the receipt of their scores on the Graduate Record Examinations, may be admitted as unclassified students. When evaluation of completed transcripts or satisfactory performances on the Graduate Record Examinations warrant, such students may be transferred during the semester to full or provisional status. Unless transcripts or Graduate Record Examination scores are received within a reasonable time after admission or when evaluation of transcripts or scores on the Graduate Record Examinations indicate unsatisfactory qualifications for graduate study, no graduate credit may be received for course work.

Registration—The Office of Registration must have written authorization from the dean of the Graduate School before any graduate student will be given a permit to register. This authorization will be sent to the Office of Registration by the graduate dean at the time the student is notified of his acceptance.

Physical Examinations—All regularly enrolled graduate students must take a physical examination preferably given by the family physician and the results recorded on forms provided by the College. When this is not done the examination may be given by the College physician during registration for a fee of \$5.00.

Public school personnel (primary teachers, secondary teachers, or administrators) registering at State College for the first time who are interested primarily in "Certification Credit" may enroll as graduate students for a maximum of six semester hours without forwarding official transcripts of previous work to the Graduate Office. If, however, application is not made through normal channels for graduate credit in the session in which the course or courses are taken, the student will not be permitted to apply the credit toward an advanced degree, at State College, or elsewhere.

In all cases where the teacher's interest is primarily in approval for certification credit, the School of Education will be responsible for assessing the adequacy of the teacher's qualifications for enrollment in the College and in the particular course or courses. The School of Education will also be responsible for advising all such students early in each school session that if they wish for their credits to be applied in due course to a higher degree at State College, or elsewhere, normal admission procedures will be required.

All teachers who have previously attended State College and earned six semester hours of credit and wish to enroll for additional courses for graduate credit will be required to make application for admission to the Graduate School in the usual manner, if they have not already done so.

In all cases a "B" level of academic performance or better is required.

Course Load—A full-time graduate load is considered to be fifteen credits per semester. This course load restriction is made so that graduate students may have time for reading and contemplation well beyond the limits set for satisfactory undergraduate work. In exceptional cases one or two additional credit hours may be added to the roster if necessary in order to get prerequisite work which is not taught in subsequent terms, provided the corresponding adjustment in course load is made in the other terms. Rosters with additional credit hours beyond fifteen should be accompanied by a special note from the head of the major department indicating the reasons for the additional work.

Full-time employees of the College may register for or audit one course in each semester upon the recommendation of their dean and the approval of the dean of the faculty.

Employees of the College having academic rank higher than instructor may register for graduate work for credit to be transferred to other institutions. They may not undertake programs for graduate degrees in the Consolidated University of North Carolina.

Graduate assistants on half-time appointments are permitted a maximum course load of nine credits per semester unless corresponding adjustments are made in their service obligations during the same semester. If the appointment is for the academic year of nine months, half-time assistants are restricted to a maximum of eighteen credit hours of work during the nine months of their appointment. Half-time graduate assistants whose appointments are for twelve months may not exceed a total of twenty-four credits during the twelve month period of their appointment. Three-quarter



State College's Memorial Tower was completed in 1949.

time graduate assistants whose appointments are for twelve months may register for a total of sixteen credits during the calendar year. A total of six credits is the maximum load in a regular semester.

A member of the State College senior class may, upon approval of the dean of the Graduate School, register for courses in the 500 group for graduate credit to fill a roster of studies not to exceed fifteen credits in any semester. Not more than six hours of graduate credit may be acquired by an undergraduate student. Courses listed with numbers in the 600 series are not ordinarily open to undergraduates. Occasional exceptions may be made for "honor" students.

GRADUATE DEGREES

Admission to the Graduate School does not constitute admission to candidacy for a graduate degree. Application for admission to candidacy for graduate degrees must be submitted to the Administrative Board of the Graduate School. Application of students preparing for the master's degree may not be filed before the satisfactory completion of one full semester of graduate study and must be presented before the end of the first week of the last semester in residence. Approval of the application will be determined by the quality of the scholastic record and on the certification by the major department that the student is qualified to continue advanced work. Admission to candidacy for the doctorate is granted upon satisfactory completion of the qualifying or preliminary examinations.

The N. C. State College Graduate School offers work leading to the Master of Science degree in the specialized branches of agriculture, education, engineering, forestry, physical sciences and applied mathematics, and textiles; the Professional Master's degree in agriculture, agricultural education, and forestry; and the Doctor of Philosophy degree in certain fields of agriculture, engineering, forestry, and physical sciences and applied mathematics.

A graduate student is expected to familiarize himself with the requirements for the degree for which he is a candidate and is held responsible for the fulfillment of these requirements. This applies to the last dates on which theses may be accepted, the dates for examinations, the proper form of theses, and all other matters regarding requirements for degrees.

Master of Science Degree

The Master of Science degree is awarded at State College after a student has completed a course of study in specialized fields in agriculture, education, engineering, forestry, physical sciences and applied mathematics, or textiles; demonstration of ability to read a modern foreign language; completion of a satisfactory thesis and of comprehensive examinations in the chosen field of study.

In addition to complying with these requirements, the candidate for the Master of Science degree is expected to achieve high levels of scholarship. Graduate study is distinguished from undergraduate work by its emphasis upon independent research. The graduate student is more interested in the significance of facts than in the accumulation of data. He is concerned with the materials of learning and the organization and interpretation of these materials.

A graduate student's program of study is planned so as to provide a comprehensive view of some major field of interest and to furnish the training essential for successful research in this field and related areas of knowledge. As great a latitude is permitted in the selection of courses as is compatible with a well-defined major interest. The program of course work is selected with the object of making possible a reasonable mastery of the subject matter in a specialized field. Training in research is provided to familiarize the student with the methods, ideals, and goals of independent investigation. Since there are many possible combinations of courses, the administration of graduate programs calls for personal supervision of each student's plan of work by a special advisory committee of the graduate faculty. (See page 15). The program of course work to be followed by the student as a part of the requirements for the master's degree and the thesis problem selected must be approved by the student's advisory committee and the dean of the Graduate School.

Credits

1. For the Master of Science degree a minimum of thirty semester credits is required.
2. No more than six of the academic credits required for the degree will be accepted from other institutions.
3. No graduate credit will be awarded for excess undergraduate credit from another institution.
4. All work credited toward a master's degree must be completed within six calendar years.
5. No graduate credit is allowed for courses taken by correspondence. A maximum of six semester credits may be obtained in extension study in

the field of education provided the extension courses are taught by a member of the graduate faculty and provided the courses are given graduate ranking by the Graduate School. Courses taken by extension are accepted for graduate credit only when the student has been admitted to the Graduate School and when notice of his registration is filed with the Graduate Office. Credit for extension courses reduces the amount of credit that may be transferred from other institutions by the amount of graduate credit granted.

The thirty semester credit hour requirement for the master's degree represents the minimum quantity of work acceptable. The credit hours required of graduate students usually exceed the minimum requirements. Inadequate preparation and thesis research frequently make additional work necessary.

Courses of Study

The program of the student shall include at least eight semester credits in courses of the 600 group, no more than six of which may be allowed for research study. A maximum of two hours of seminar is permitted. Graduate students may use not more than six semester hours of course work of the 400 level for credit on programs leading to the master's degree. To be acceptable for graduate credit, courses bearing a 400 number must fall in fields other than the student's major field of interest.

During the first term in residence an advisory committee of at least three faculty members, one representing the minor field, will be appointed by the dean, after consultation with the head of the major department, for each student engaged in a program of work leading to the master's degree. The advisory committee will meet with the student and prepare a program of course work to meet the requirements of the student's graduate objectives. Four copies of the program, prepared on forms provided for this purpose, must be approved by each member of the committee, by the head of the major department, and by the dean of the Graduate School. After approval has been made in the Graduate Office, three copies will be returned to the department head, one for his files, one for the chairman of the advisory committee, and one for the student.

The courses taken by a graduate student shall constitute a well-rounded but unified plan of study. This means that the program of research and course work shall be divided between a major and a minor field. While there are no inflexible rules which govern the number of credit hours that must constitute the major and minor, in general, it is expected that approximately two-thirds of the course work will fall in the major and one-third in the minor. The detailed course requirements for each graduate student program are left to the judgment of the advisory committee.

Residence

Students engaged in a course of study leading to the Master of Science degree are required to be in residence at the College, pursuing graduate work, one full academic year.

Class Work

A graduate student is expected to show greater initiative in exploring the possibilities of the subject matter presented in the courses he takes than is the undergraduate. He is also expected to recognize the significance of

facts and to assume a responsibility for relating data to theoretical concepts. In preparation, attendance, and in all the routine of class work the graduate student is subject to the regulations observed in other divisions of the College.

Grades

A minimum grade of "C" must be made on all formal course work to obtain graduate credit. An average of "B" must be obtained on all course work taken as a part of the student's graduate program. Failure to maintain a "B" average in any term will place the student on probation. Any student whose academic record fails to meet the "B" average requirement for two consecutive terms will not be permitted to continue a graduate program without the written approval of the dean.

Grades in research, seminar, and special problem courses are given in terms of "S" (*satisfactory*) or "U" (*unsatisfactory*) in place of the symbols used for formal course work.

The grade *incomplete* may be used in research and laboratory courses when circumstances beyond the control of the student have prevented completion of the work by the end of the academic term. An incomplete grade may be given only after approval by the dean and must be converted to one of the usual symbols before the end of the next academic semester in which the student is in residence.

Language Requirements

A reading knowledge of at least one modern foreign language (Germanic, Romance, or Slavic) is required of candidates for the Master of Science degree.

The language requirement must be satisfied before a student can be admitted to candidacy.

Proficiency in languages is determined by the Department of Modern Languages:

1. By traditional reading knowledge examination at any time requested by the student.
2. By taking course work (audit) especially designed for graduate students who have no previous foreign language experience or who wish to refresh work formerly done. The department offers special courses beginning with elementary grammar and proceeding in the course of the semester to general scientific reading. Pronunciation is emphasized to the degree to which it will help in translating from the language into English. This first course is followed by a second course in which the student selects work from scientific publications touching as nearly as possible his major interest. He will then be assigned a particular instructor with whom he will read in individual conferences. When the conference instructor is satisfied that the student has demonstrated his knowledge of intricate grammatical problems, a decrease in the time required for reading, and a confidence in his ability to use the language, he will be certified without further examination. The completed translations may then, depending upon their merit, be edited and prepared for permanent filing with the various translation libraries throughout the country.

Graduate students who expect to complete the requirements for the Master of Science degree should confer with the head of the Department of Modern Languages soon after registration to formulate plans for meeting the language requirement of this degree.

Students whose native language is other than English may meet the foreign language requirement for the Master of Science degree by demonstrating a satisfactory mastery of English. Examinations in English are conducted by the English Department.

Thesis

A candidate for the Master of Science degree must prepare a thesis representing an original investigation. The subject of the thesis must be approved by the head of the department in which the major work is done and by the student's advisory committee. Three copies of the thesis in final form and five copies of the abstract must be filed in the Graduate Office at least one month before the degree is awarded. The abstract will be published by the College. Detailed instructions as to form and organization of the thesis may be obtained at the Graduate Office.

Examinations

All candidates for the Master of Science degree must pass, with a grade of "A", "B", or "C", all formal course work specified as part of the requirements for the degree. Graduate credit for research, seminar, and special problem courses is granted when a grade of "S" is recorded in the Registration Office. In addition, the candidate must pass a comprehensive oral examination that is held to satisfy the examining committee that the candidate possesses a reasonable mastery of knowledge in the major and minor fields and that this knowledge can be used with promptness and accuracy. This examination may not be held until all other requirements, except completing the course work of the last semester, are satisfied but must be taken not later than two weeks before the end of the semester in which the degree is to be awarded. Application for the comprehensive oral examination must be filed with the graduate dean by the chairman of the advisory committee at least one week prior to the date on which the examination is to be held.

The oral examination will be conducted by an examining committee appointed by the graduate dean. The chairman of the examining committee will be the chairman of the student's advisory committee. At least two additional members will be appointed to represent the major and minor fields. The comprehensive oral examination is open to all faculty members who care to attend but the decision as to the candidate's fitness rests solely with the examining committee.

At the discretion of the examining committee, written examinations covering the subject matter in the major and minor fields also may be required of the candidate. Written examinations, when required, may not be held earlier than the end of the first month of the last semester in residence, and not later than one week before the comprehensive oral examination.

The final examination for candidates for the master's degree may not be scheduled until the thesis, in complete and final form, signed by the chairman of the student's advisory committee, has been submitted to the Graduate Office.

Master's Degree in a Professional Field

This degree is offered for students who are interested in the more advanced applications of fundamental principles to specialized fields rather than in the acquisition of the broader background in the advanced scientific studies

which would fit them for careers in research. Students working for this degree ordinarily will terminate their graduate work at this point.

Examples of the types of degrees that may be awarded upon the completion of the course of study in a professional field are Master of Agricultural Education, Master of Forestry, and Master of Agricultural Engineering.

The degree is not offered in the Schools of Engineering, Physical Sciences and Applied Mathematics, or Textiles.

The chief characteristic of these degrees is that the changes made in requirements permit, in greater measure, the satisfaction of what are represented as professional needs than do the requirements for the conventional Master of Science degree. The most important modification in the requirements is the greater emphasis upon the applied rather than the basic sciences.

Language Requirements

The candidate for a master's degree in a professional field is exempt from the requirements of a reading knowledge of a modern foreign language.

Thesis Requirements

In the School of Education the thesis requirement for the master's degree in each of the specialized fields may be waived by the department in which the degree is sought. When the thesis requirement is waived the student must complete the course "Introduction to Educational Research," or a departmental course in research and a problem report. A thesis is required for the professional degree in agriculture and forestry.

Other Requirements

The other requirements for the master's degree in a professional field are the same as for the Master of Science degree.

Master of Agriculture Degree

This plan is offered for the students who are interested in advanced training in the broad field of agriculture but whose responsibility is not in research. The requirements for the degree are designed to provide an opportunity for professional training without narrow specialization for those who plan to devote their lives to some phase of practical agriculture. Among the individuals interested in this degree are agricultural extension workers and foreign students who are in action or educational programs. The proposed plan differs from the plan for the Master of Science degree in the following principal respects:

1. A total of thirty-six semester credits is required.
2. A minimum of four semester credits in special problems is required. Not more than six semester credits in special problems will be allowed. This work replaces the research thesis requirement for the Master of Science degree.
3. There are no specific requirements as to courses in the 600 group.
4. A reading knowledge of a modern foreign language is not required.

In all other respects the requirements for the Master of Agriculture degree are the same as those for the Master of Science degree.

A Summary of Procedures for the Master's Degree

1. Letter of inquiry from prospective student to Graduate Office or department head.

2. Mailing of proper forms to student by Graduate Office or department head.

3. Receipt of application form and transcript by Graduate Office.

4. Application with transcript sent to department head for study.

5. Department head recommends acceptance of prospective student stating curriculum in which he will work and the degree sought.

6. Assuming the prospective student meets the minimum scholastic standards, notice of acceptance is mailed to him by the Graduate Office. When the student's academic record fails to meet the minimum scholastic standards of the Graduate School, provisional admission may be granted upon submission by the student of evidence of a satisfactory performance on the Graduate Record or National Teacher's Examinations. The National Teacher's Examination is accepted only when approved by the department head and the graduate dean.

7. Permit to register is sent by the Graduate Office to the registrar.

8. Student arrives, reports to the department head, is assigned an adviser, and makes out a roster of courses in consultation with departmental adviser.

9. Advisory committee of three or more faculty members, one of whom represents the minor field, appointed before the end of the first semester of graduate study by the Graduate Office after consultation with the department head.

10. Plan of work prepared by the advisory committee in consultation with the student and submitted in quadruplicate to the Graduate Office by the end of the first semester in residence.

11. Plan of work approved by the graduate dean and three copies returned to the department head. One copy is kept in department files, one goes to the adviser, and one is given to the student.

12. A thesis subject is selected and an outline of the proposed research submitted to the department head and to the student's advisory committee. Students preparing themselves for the professional degree in specialized fields of education should consult the chairman of their committees with reference to their problem report.

13. Student passes language examination. Students preparing themselves for the master's degree in a professional field are not required to pass a language examination. The language requirement must be satisfied before admission to candidacy can be granted.

14. Student applies for admission to candidacy for the master's degree. Application must be filed before the end of the first week of the last semester in residence and may not be filed before the language requirement is satisfied.

15. Application is reviewed by the head of the major department and by the Administrative Board and if approved the student becomes a candidate for the degree.

16. A copy of a preliminary draft of the thesis is submitted to the chairman of the student's committee for criticism. No thesis is required of the candidate for the master's degree in specialized fields of education.

17. Corrected draft of the thesis submitted to members of the student's advisory committee for additional suggestions and criticisms.

18. Three copies of the thesis in final form approved by each member of the student's advisory committee and signed by the adviser are submitted to the Graduate Office at least one month prior to awarding of the degree.

19. Permission for student to take final examination requested of Graduate Office by chairman of student's advisory committee at least one week

before the examination is to be held. Permission will not be granted until thesis in final and complete form has been received in the Graduate Office.

20. Permission granted by graduate dean—date is set and examining committee appointed.

21. Report of the examination sent to the Graduate Office at least two weeks prior to the date the degree is to be awarded.

22. Graduate Office certifies to the Registration Office and to the general faculty that all requirements for the degree have been met and recommends the awarding of the degree.

23. Student must be registered in term in which degree is to be awarded.

Doctor of Philosophy Degree

The degree of Doctor of Philosophy is offered in the following departments:

- Agricultural Economics
- Agricultural Engineering
- Animal Science
- Applied Mathematics
- Applied Physics
- Botany and Bacteriology (in the fields of bacteriology, physiology and ecology)
- Chemical Engineering
- Civil Engineering
- Crop Science
- Electrical Engineering
- Entomology
- Experimental Statistics
- Food Science
- Forestry
- Genetics
- Mechanical Engineering
- Mineral Industries (in the field of ceramic engineering)
- Nuclear Engineering
- Plant Pathology
- Rural Sociology
- Soil Science
- Zoology (in the fields of ecology and wildlife biology)

The doctor's degree symbolizes the fact that the recipient is capable of undertaking original research and scholarly work at the highest levels without supervision. Therefore, the Doctor of Philosophy degree is not granted on a basis of the successful completion of a given amount of course work, but rather upon the demonstration by the candidate of a comprehensive knowledge and high attainments in scholarship and research in a specialized field of study. These attainments are determined by the quality of the dissertation which the candidate prepares to report the results of original investigations and by passing successfully a series of rigorous and comprehensive examinations on the special and related fields of study.

Course of Study

At the time of admission the student should, with the advice of the chairman of the department, elect a major field. During the student's first semester in residence, an advisory committee of at least five members will

be appointed by the graduate dean, after consultation with the department head, to prepare with the student a plan of graduate work. Four copies of the program, signed by all members of the advisory committee and the department head or graduate administrator, are referred to the graduate dean for approval. When approved three copies are returned to the department head, one being retained in the department files, a second copy is given to the chairman of the advisory committee, and the third copy is given to the student. The subject of the dissertation must appear on the plan of work, and any subsequent changes in the subject of the thesis or in the plan of graduate work must be reported to the Graduate Office for approval.

There are no definite requirements in credit hours for the doctor's degree. Emphasis is placed upon a comprehensive knowledge of a well defined and recognized field and related subjects. Each student will have a major and one or two minor areas of specialization. The minor field ordinarily will consist of at least twenty semester credit hours. These may fall in an allied department or in the major department. A minor in the department of the major is permitted only when the department offers recognized divisions of study other than that designated as the major field.

Residence

For the Doctor of Philosophy degree, the student is expected to be registered for graduate work for at least six semesters beyond the bachelor's degree at some accredited graduate school. The amount of work from other institutions credited to the fulfillment of degree requirements will be determined by the dean after consultation with the student's advisory committee at the time the plan of graduate work is filed.

At least two residence credits, as defined below, must be secured in continuous residence (registration in consecutive semesters) as a graduate student at some branch of the Consolidated University of North Carolina. Failure to take work during the summer does not break the continuity; however, summer school work can be used to fulfill this requirement.

Residence credit is based on the number of credits of graduate work beyond the bachelor's degree carried in a given term. During a regular semester, residence credit is calculated in the following manner:

<i>Semester Credits</i>	<i>Residence Credits</i>
9 or more	1
6 - 8	$\frac{2}{3}$
less than six*	$\frac{1}{3}$

The residence credit for a six-week summer term is only one-half the corresponding amount for a regular semester; i.e., six semester credits carry $\frac{1}{3}$ residence credit and less than six credits, $\frac{1}{6}$ residence credit. If a student registers for a twelve-week summer term, the residence credit is computed as for regular semesters. If a student registers for both twelve-week and six-week summer terms, the residence credit is computed separately for each type and totaled, with the stipulation that no more than one residence credit can be earned in a given summer.

The candidate must complete all requirements for the degree, including the final examination on his dissertation, within a period of seven calendar years from the date of admission to candidacy for the degree.

* Including registration for thesis preparation on campus.

Languages

A reading knowledge of scientific literature in two modern foreign languages or a comprehension in depth of one language is required for the Doctor of Philosophy degree.

Comprehension in depth is to be interpreted as a proven ability in the oral and composition elements of a particular language as well as the reading knowledge normally required. Ph. D. students desiring to offer one language in depth should consult with the head of the Modern Languages Department as to the specific courses to be followed to achieve this comprehension. Specific arrangements may differ depending upon the student's previous background in the language. It is emphasized that students choosing to achieve competence in depth in one language will generally find this alternative more rigorous than proof of reading ability in two languages.

If the student elects to work in two languages, the languages may be a combination of Romance and Slavic, Romance and Germanic, or Slavic and Germanic.

Students whose native tongue is some language other than English may use English as one of the languages required for the Doctor of Philosophy degree. When English is submitted in partial fulfillment of the language requirements, the native language may not be used to satisfy the language requirements.

Examinations in English will be given by the English Department, and a statement certifying the candidate's proficiency in English must be filed in the Graduate Office before the qualifying examination may be taken.

The Dissertation

The doctoral dissertation presents the results of the candidate's original investigations in the field of his major interests. It must represent a contribution to knowledge adequately supported by data and written in a manner consistent with high standards of excellence in scholarship. Detailed instructions relating to the thesis may be obtained from the Graduate Office.

Publication of the results obtained in the thesis investigation is expected. Each copy of the thesis must be accompanied by an abstract of approximately 500 words. The abstract will be published by the College.

The dissertation will be examined by all members of the examining committee and must receive their approval to be acceptable to the Graduate Office.

Two copies of the dissertation in final form and signed by the chairman of the student's advisory committee must be presented to the Graduate Office not later than six weeks before the date of which the degree is to be awarded.

North Carolina State College now has an agreement with University Microfilms, Inc., of Ann Arbor, Michigan, by which all doctoral dissertations are microfilmed and abstracts of the dissertations are published in *Dissertation Abstracts*.

Examinations

Not earlier than the end of the second year of graduate study and not later than the end of the third week of the academic year in which the degree is expected, each doctoral student is required to pass general comprehensive examinations (known as the qualifying or preliminary examinations). If summer sessions are involved, the interval between the date of the

qualifying examinations and anticipated date of the awarding of the degree may be interpreted as including two consecutive summer sessions and one academic semester. The examinations are given by an examining committee of graduate faculty members appointed by the graduate dean after consultation with the head of the department in which the student's major work has been taken. The examining committee usually consists of the student's advisory committee and a representative of the Graduate School, but may include other members of the graduate faculty. The examinations are open to all members of the graduate faculty who may care to attend.

Authorization for the qualifying examination is requested of the Graduate School by the chairman of the student's advisory committee when the major part of the student's program of course work has been completed and when, in the judgment of the committee, the student is prepared to devote the greater part of his time to the prosecution of his research study. Members of the examining committee will be notified of their appointment by the Graduate Office. Official printed forms will be supplied to the chairman of the examining committee for a report of the results of the examination.

The examination consists of two parts: (1) written examinations prepared separately by each member of the examining committee and (2) an oral examination held before the entire examining committee. Upon receiving authorization for holding the qualifying examination, the chairman of the examining committee will request examination questions from each member of the examining committee. Each set of questions will be given to the student by the chairman of the examining committee in any order that may seem appropriate. The questions together with the student's answers will be returned to the members of the committee for grading. The questions may cover any phase of the course work taken by the student during the period of his graduate study or any subject logically related and basic to an understanding of the subject matter of the major and minor areas of study. They should be designed to measure the student's mastery of these subject matter fields and the adequacy of his preparation of research investigations.

Upon satisfactory completion of the written examinations the student must pass an oral examination before the entire examining committee. This examination is usually held within a week after the written examination. The members of the examining committee will be notified by the Graduate School of the time and place arranged for the oral examination. The oral examination is designed to test the student's ability to relate factual knowledge to specific circumstances. In the oral examination the student is expected to use his knowledge with accuracy and promptness and to demonstrate that his thinking is not limited to the facts learned in course work.

When the examining committee consists of five members, a unanimous vote of approval is required for passing the preliminary examination. Approval may be conditioned, however, upon the completion of additional work in some particular field to the satisfaction of the committee. In case a single dissenting vote is cast in a five member committee, the course of action to be taken will become a matter for decision by the Administrative Board. Upon receiving the approval of the examining committee the student is admitted to candidacy for the doctorate.

A final oral examination is also required. During a normal academic year, an interval of at least eight months must elapse between admission to candidacy and the final oral examination. If summer sessions are involved, this interval may be interpreted to include two consecutive summer sessions and one academic semester.

This examination is held after the dissertation has been completed and consists of a defense by the candidate of the methods used and the conclusions reached in his research study. The examination is conducted by an examining committee. The examining committee usually includes the student's advisory committee, plus a representative of the Graduate School, although this procedure is not always adopted. The examining committee is appointed by the graduate dean after consultation with the head of the student's major department.

The final oral examination may not be scheduled until the dissertation in complete and final form, signed by the chairman of the student's advisory committee as evidence of committee approval, has been submitted to the Graduate Office.

Failure of a student to pass either the preliminary or the final examination terminates his graduate work at this institution unless otherwise recommended by the examining committee. No re-examination may be given until at least one full semester has elapsed since the first examination. Only one re-examination is permitted.

Admission to Candidacy

A student is admitted to candidacy after he has successfully passed the preliminary examinations. The language requirements must be fulfilled before permission to take the preliminary examination is granted. Admission to candidacy must be obtained before the end of the third week in the academic year in which the degree is expected; i.e., nearly two semesters before the degree is awarded.

Additional Information

A booklet containing detailed instruction about the form of dissertation may be obtained at the Graduate Office.

Further information concerning graduate work at State College may be secured from Dr. Walter J. Peterson, Dean of the Graduate School, N. C. State College, Raleigh, N. C.

Summary of Procedures for Doctor of Philosophy Degree

1. Letter of inquiry from prospective student to Graduate Office or department head.
2. Mailing of proper forms to student by Graduate Office or department head.
3. Receipt of application forms by Graduate Office.
4. Application with transcript sent to department head for study.
5. Department head recommends acceptance of prospective student stating curriculum in which he will work.
6. Assuming the prospective student meets the minimum scholastic standards, notice of acceptance is mailed to him by the Graduate Office.
7. Permit to register is sent by Graduate Office to the registrar.
8. Student arrives, reports to the department head, is assigned an adviser, and makes out a roster of courses in consultation with departmental adviser.
9. Advisory committee of at least five members is appointed in the first term of graduate study by the graduate dean after consultation with the department head.
10. Plan of work prepared by the advisory committee in consultation with the student and submitted in quadruplicate to the Graduate Office by the end of the first semester in residence.

11. Plan of work approved by the graduate dean and three copies returned to the department head. One copy is kept in department files, one goes to the adviser, and one is given to the student.

12. A dissertation subject is selected and an outline of the proposed research submitted to the department head and the student's advisory committee.

13. Student passes language examinations.

14. The chairman of the student's advisory committee requests permission to hold the qualifying examination. This must be done not earlier than the end of the second year of graduate study and not later than eight months (two semesters or one semester and two summer sessions) before the date on which the degree is to be awarded.

15. Permission to take qualifying examination granted by graduate dean if the student's record is in order. A date is set and examining committee appointed. The examination consists of two parts—a written and an oral.

16. A report of the examination is sent to the Graduate Office. If the report is favorable, the student is admitted to candidacy.

17. A copy of a preliminary draft of the dissertation is submitted to the chairman of the student's committee for criticism.

18. Corrected draft of the dissertation submitted to members of the student's advisory committee for additional suggestions and criticisms.

19. Two copies of the dissertation in final form approved by each member of the student's advisory committee and signed by the adviser are submitted to the Graduate Office at least six weeks prior to awarding of the degree.

20. Eight months after admission to candidacy or later, permission for the candidate to take the final oral examination is requested of the Graduate School by the chairman of the candidate's advisory committee. Requests should be filed at least one week before the date of the examination.

21. Permission granted by graduate dean if the student's record is in order. A date is set and examining committee appointed.

22. Report of the examination sent to the Graduate Office at least one week prior to the date on which the degree is to be awarded.

23. Graduate Office certifies to the Registration Office and to the general faculty that all requirements for the degree have been met and recommends the awarding of the degree.

24. Student must be registered in the term in which the degree is to be awarded.

State's ultra-modern Student Supply Store was completed in 1959.



TUITION AND FEES

Tuition rates for students enrolled in the Graduate School at State College are as follows:

North Carolina resident—\$9 per semester hour for each semester hour of enrollment up to and including nine semester hours. For ten semester hours or more, \$87.50 for the semester.

Non-resident—\$32 per semester hour for each semester hour of enrollment up to and including nine semester hours. For ten semester hours or more, \$300 for the semester.

Incidental fees and charges are levied for purposes and services available to all graduate students whether or not the student takes advantage of them. The full amount of incidental fees and charges will be collected, notwithstanding the number of semester hours of credit for which the student may enroll.

For the academic year 1962-63, fees are as follows:

First semester	\$71
Second semester	\$65

In cases of occasional or part-time graduate students not in residence, application for cancellation of non-academic fees may be made if it is clear that the student could not use the services covered. Application forms are available in the Graduate School and College Business Offices.

Full-time staff or faculty members may be permitted to take one course per semester on the N. C. State College campus at a flat rate of \$15 per semester or to audit one course without charge, in either case upon the recommendation of their dean and approval of the dean of the faculty. This payment does not include non-academic fees, and none of the privileges attendant upon the payment of such fees is allowed. Forms for this approval are available in the office of the dean of the faculty.

Faculty members on less than full-time appointments will be permitted to take more than one course per semester upon the recommendation of their dean and the approval of both the dean of the Graduate School and the dean of the faculty. In these cases tuition and fees will be the same as those for part-time graduate students computed at residence rates.

Maximum permissible course loads for graduate students holding part-time appointments are as follows: Three quarters time, six hours; half-time, nine hours; quarter time, twelve hours.

Students wishing to visit classes without participation in class discussions, quizzes, or examinations must register for this privilege as auditors. *Visiting classes without registration is not permitted.* Graduate students may register for one course as an audit in any semester without charge when the audit is certified by the dean of the Graduate School as a part of course work for which tuition charges are made (this does not apply in the summer sessions).

Audits in subjects in which the student has had no previous experience will be evaluated at full credit value in determining course loads. Audits taken as repetition of work previously accomplished are considered at one half their credit value in calculating course loads. With the single exception of foreign language audits, all audit registrations must fall within the maximum permissible course loads. Audits are not permitted students registering for thesis preparation. While audit registrations are evaluated for purposes of determining permissive course loads in terms of the above regulations of the Graduate Office, the Business Office considers all audits, excepting the one permitted free of charge, in terms of full credit value in calculating the tuition for graduate students.

All graduate students holding college appointments of 1/3 service obligation or more and receiving a regular monthly salary check are charged the resident or "in-state" rate of tuition.

Formerly, a non-resident student holding a non-service grant paying him at least \$1,000 for nine months was entitled to a special tuition rate of \$180 per semester. This is no longer the case.

Graduate students who have completed all course work and residence requirements and who are in residence for the purpose of writing a thesis or dissertation may register for "thesis preparation." The tuition charge for this registration is \$15. Students registering for thesis preparation will pay in addition a non-academic fee of \$38 in the fall semester and \$32 in the spring semester.

Graduate students not in residence who have completed all requirements for the degree sought, including the thesis and final examination, will be required to register for "degree only" in the semester in which the degree is awarded. The charge for this registration is \$10.

A diploma fee of \$12 is charged all students receiving a master's degree and a fee of \$17 is charged all students who receive a doctorate. A fee of \$21 is charged all doctoral candidates for microfilming their dissertations.

Anyone who feels a mistake has been made in his bill may discuss the matter with the Business Office. Any further appeals should be made to the College Committee on Refund of Fees. Forms for this appeal may be obtained at 101 Holladay Hall.

All tuition charges and fees are subject to change without notice.

Fees for Summer School

Registration Fee	\$11.00
Tuition (In-State Students per credit hour)	\$ 7.50
Tuition (Out-of-State Students per credit hour)	\$18.50
Audits (per credit hour)	\$ 7.50

In order to draw a clear line between in-state and out-of-state students, the Administration has ruled that all students whose parents have not been domiciled in North Carolina for more than six months immediately preceding the day of their first enrollment in the institution shall be termed out-of-state students, with the following exceptions:

- (1) Students twenty-one years of age at the time of their first matriculation who have resided in North Carolina for more than one year preceding the day of their first enrollment;
- (2) Children of regular employees of the Federal Government stationed in the State of North Carolina; and
- (3) Children of regular employees of the Federal Government who are employed outside of the State, but who through law are permitted to retain their North Carolina citizenship.

Students cannot claim a change in their resident status after matriculating. Students furnishing incomplete or incorrect information in order to obtain the special State-resident status shall be liable for dishonorable dismissal.

Graduate students employed by the College or the Experiment Station on a part-time basis are not permitted to register for a full-time load of course work. The Veterans Administration will classify such students as full-time students when it is officially certified by the dean of the Graduate School that the student is engaged in a full-time program of professional work.

FELLOWSHIPS AND GRADUATE ASSISTANTSHIPS

Fellowships

Graduate fellowships are funds offered to graduate students to assist in the support of programs of advanced study. Holders of fellowships have no service obligations to the College and may devote full time to the prosecution of their graduate programs.

Some of the agencies sponsoring fellowships at North Carolina State College are the Celanese Corporation, DuPont Company, Eastman Kodak Company, Edward Orton, Jr. Ceramic Foundation, General Foods Corporation, Honor Society of Phi Kappa Phi, Kellogg, Mortex Chemical Products, N. C. Grange (E. G. Moss Fellowship), National Science Foundation, Office of Education of the Department of Health, Education and Welfare, Rockefeller Foundation, Sperry Gyroscope Company, Union Carbide Corporation, and Westinghouse.

Information relative to stipends, areas of research study supported by specific fellowships, and application forms may be obtained from the Graduate School or from the heads of the appropriate departments.

Assistantships

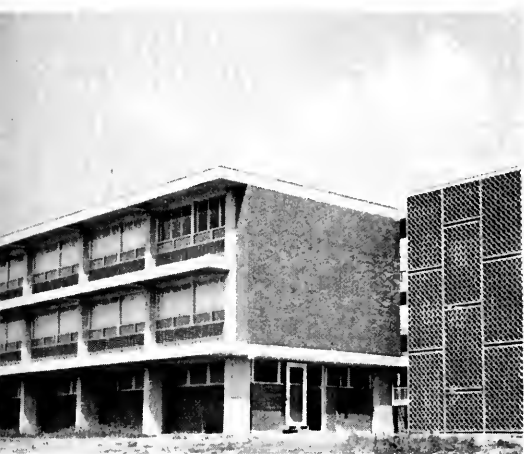
Graduate assistantships are granted to selected students who devote some part of their time to service duties for the College. Teaching assistantships carry a stipend of \$2,400 for the academic year and permit the holder to enroll for sixty per cent of a full course load. The stipends for research assistantships range from \$2,400 to \$2,700 for a 12 months' appointment. The College offers 350 assistantships which require a service obligation in either teaching or research. Some of these are supported by funds granted by the following agencies: the American Potash Institute, the Atomic Energy Commission, Best Foods, Campbell Soup Company, the Chilean Nitrate Education Bureau, Inc., Gerber Products Company, Hercules Powder Company, the Lilliston Implement Company, the Lilly Company, the McLean Trucking Company, National Cotton Council, the North Carolina Agricultural Foundation, the North Carolina Dairy Foundation, the North Carolina Department of Motor Vehicles, the North Carolina State Optometric Society, the Office of Naval Research, the Pacific Coast Borax Company, the Ralston-Purina Company, the Tennessee Corporation, the Solvay Process Division of the Allied Chemical Company, and the Union Carbide Chemicals Company.

William D. Carmichael Gymnasium is sportsman's paradise.



RESIDENCE FACILITIES

Dormitory facilities are provided on the campus for unmarried graduate students. The rental charge for double rooms is \$85 per semester. A limited number of apartments are provided for married graduate students.



Views of McKimmon Village (married student housing) are shown.



FIELDS OF INSTRUCTION

Departmental Announcements and Description of Courses*

DEPARTMENT OF AGRICULTURAL ECONOMICS

Graduate Faculty

Professors: CHARLES EDWIN BISHOP, *Head*, GEORGE L. CAPEL, H. BROOKS JAMES, RICHARD ADAMS KING, JAMES GRAY MADDOX, WALTER HENRY PIERCE, GEORGE STANFORD TOLLEY, WILLIAM DOUGLAS TOUSSAINT

Associate Professors: ARTHUR JAMES COUTU, WILLIAM RAY HENRY, JAMES ARTHUR SEAGRAVES, ANTHONY PAUL STEMBERGER, JAMES CLAUDE WILLIAMSON, JR.

Assistant Professors: RICHARD LEE SIMMONS, THOMAS DUDLEY WALLACE

USDA Agricultural Economist: JOSEPH GWYN SUTHERLAND

The Department of Agricultural Economics offers programs of study leading to the Master of Agricultural Economics, the Master of Science and the Doctor of Philosophy degrees. Special emphasis is placed on the economics of agricultural production and marketing, analysis of programs and policies affecting agriculture and statistical techniques used in solving economic problems of the agricultural industry. The curriculum includes courses in advanced economic theory with special adaptation to agricultural problems including the use of econometric and linear programming techniques. Business management analysis, operations analysis and programming of firm and industry decisions are emphasized. Special attention is given to public policies influencing regional and national agricultural adjustments.

Collateral fields of study include statistics, rural sociology, history and political science, general economics, agricultural education, and various technical departments in the School of Agriculture.

As a part of their advanced training, students are required to prepare a thesis dealing with a recognized problem in agriculture. This part of the program affords an opportunity to learn how to apply theory and analytical techniques in the solution of agricultural problems.

The rapid growth and development of industry and agriculture in North Carolina and throughout the South have resulted in an increased demand for well-trained workers throughout the region. Opportunities for employment far exceed the number of qualified workers available to perform the many duties associated with the complex and technical problems of a developing economy. Many graduates of the Department of Agricultural Economics are employed in various agencies of the Federal and State governments where they are engaged in research and educational work. Others are engaged in professional work with commercial organizations dealing in agricultural credit and the production and marketing of agricultural products.

*The course descriptions are planned for the academic years, 1962-63 and 1963-64, unless indicated otherwise. Specific courses may not be offered, however, if registration for the course or courses are too low or if faculty or facilities are not available. Courses for which graduate credit may be received are numbered in three categories. The courses in the 400 series carry no graduate credit when they are in the student's major field of interest. Graduate credit will be allowed for no more than six semester hours at the 400 level in the student's minor area of study. Courses in the 500 series are open to both seniors and graduate students. All courses in this series carry full graduate credit. Courses in the 600 series are open only to graduate students.

The department is located on the second floor of Patterson Hall. It has a modern and well equipped departmental library, including all the major professional journals and United States Department of Agriculture publications. Experiment Station publications from other institutions throughout the United States are kept on file here. Modern computational and reproduction equipment, an IBM 650 digital computer, and a Rand 1105 computer are available to the department.

Courses for Graduates and Advanced Undergraduates

AGC 512. Economic Analysis of Agricultural Factor Markets 0-3

Prerequisite: AGC 212 or equivalent

This course is oriented to the relative significance of land, labor and capital as factors of production in a modern agricultural economy, including major changes in the respective roles of these factors of production in recent years. An examination is made of the changes in characteristics of the supply and demand for these factors. The structure and efficiency of markets for these factors, including relevance of the institutional and attitudinal setting in each type of market, and nature of the demand-supply equilibration will be investigated. Public policies as they affect efficiency of the factor markets and other goals relating to the use of the basic factors of production in agriculture also will be considered.

Mr. Tolley.

AGC 521. Procurement, Processing and Distribution of Agricultural Products 0-3

Prerequisite: AGC 311 or equivalent

A study of marketing firms as producers of marketing services and their role in the pricing process; the influence of government policies on their behavior of marketing firms; methods for increasing the efficiency of marketing agricultural products.

Mr. King.

AGC 523. Planning Farm and Area Adjustments 3-0

Prerequisite: AGC 303 or equivalent

The application of economic principles in the solution of production problems on typical farms in the State; methods and techniques of economic analysis of the farm business; application of research findings to production decisions; development of area agricultural programs.

Mr. Coudu.

AGC 533. Agricultural Policy 0-3

Prerequisite: AGC 212 or equivalent

A review of the agricultural policy and action programs of the Federal Government in their economic and political setting; analysis of objectives, principal means, and observable results under short-term and long-term viewpoints, and under the criteria of resource use and income distribution within agriculture, and between agriculture and the rest of the economy; appraisal of alternative policy proposals; the effects of commodity support programs on domestic and foreign consumption, and some of the international aspects of United States agricultural policy; the attempts at world market regulation, and the role of international organizations, agreements, and programs.

Staff.

AGC 551. Agricultural Production Economics 3-0

Prerequisite: AGC 212 or equivalent

An economic analysis of agricultural production, including production functions, cost functions, programming and decision-making principles; and the applications of these principles to farm and regional resource allocation, and to the distribution of income to and within agriculture.

Mr. Toussaint.

AGC 552. Consumption, Distribution, and Prices in Agriculture **0-3**
 Prerequisite: AGC 212 or equivalent
 Basis for family decisions concerning consumption of goods and services and supply of productive factors; forces determining prices and incomes; interrelationships between economic decisions of the household and the firm. Mr. Henry.

AGC 561. Seminar in Contemporary Economic Problems in Agriculture **Maximum 6**
 Prerequisite: Senior or graduate standing and consent of the instructor
 Analysis of economic problems of current interest in agriculture. Credit for this course will involve a scientific appraisal of a selected problems and alternative solutions. Staff.

Courses for Graduates Only

AGC 602. Monetary and Fiscal Policies in Relation to Agriculture **0-3**
 Prerequisite or corequisite: AGC 501 or equivalent
 The essentials of monetary theory necessary in interpreting and evaluating monetary and fiscal operations and policies as to their effect upon income, employment, and price level; the monetary and fiscal structure, and the mechanics of monetary and fiscal operations in the United States; and the relation of monetary and fiscal policies to agricultural income and prices. Mr. Tolley.

AGC 612. International Trade in Relation to Agriculture **0-3**
 Prerequisite or corequisite: AGC 602 and 641
 The principles of international and interregional trade; structures of trade relationships between countries engaged in the import or export of agricultural products; attempts at stabilizing trade and financial transactions. Staff.

AGC 621. Research in Agricultural Economics **Credits by arrangements**
 Prerequisite: Graduate standing in Agricultural Economics, and consent of Graduate Advisory Committee
 A consideration of research methods and procedures employed in the field of agricultural economics, including qualitative and quantitative analysis, inductive and deductive methods of research procedure, selection of projects, planning and execution of the research project. Staff.

AGC 631. Economic and Social Foundations of Agricultural Policy **3-0**
 Prerequisite: AGC 501 or equivalent
 The study of logical and empirical problems of inquiry into public policies and programs that affect agriculture; analysis of policy-making processes, interdependencies among economic, political and social objectives and action; the study of forces which shape economic institutions and goals and of the logic, beliefs and values on which policies and programs that affect agriculture are founded. Staff.

AGC 632. Welfare Effects of Agricultural Policies and Programs **3-0**
 Prerequisite: AGC 642
 Description of the conditions defining optimal resource allocation; application of the conditions for maximum welfare in appraisal of economic policies and programs affecting resource allocation, income distribution, and economic development of agriculture. Mr. Bishop.

AGC 641. Economics of Production, Supply and Market Interdependency **3-0**
 Prerequisite or corequisite: AGC 501 or equivalent
 An advanced study in the logic of, and empirical inquiry into, producer

behavior and choice among combinations of factors and kinds and quantities of output; aggregative consequences of individuals' and firms' decisions in terms of product supply and factor demand; factor markets and income distribution; general interdependency among economic variables.

Messrs. Seagraves and Toussaint.

AGC 642. Economics of Consumption, Demand and Market Interdependency 0-3

Prerequisites: AGC 641 and ST 513 or equivalent

An advanced study in the theory of, and research related to, household behavior; aggregative consequences of household decisions concerning factor supply and product demand; pricing and income distribution; economic equilibrium.

Mr. King.

AGC 651. (ST 651) Econometric Methods I

0-3

Prerequisites: ST 421, ST 502, or equivalent and AGC 641

The role and uses of statistical inference in agricultural economic research; measurement problems and their solutions arising from the statistical model and the nature of the data; limitations and interpretation of results of economic measurement from statistical techniques. Topics include the problems of specification, aggregation, identification, multicollinearity and autocorrelation. Attention also is given to expectations models and simultaneous stochastic equations.

Mr. Wallace.

AGC 652. (ST 652) Econometric Methods II

0-3

Prerequisites: ST 422 and AGC 551

Techniques for problem analysis in agricultural economics; attention to analysis of time series data; non-parametric inference; experimental design in economic research; estimation of parameters in production functions and in simultaneous models; selected special topics.

Mr. Anderson.

AGC 671. Analysis of Economic Development in Agriculture

3-0

Prerequisite: AGC 641

A theoretical and empirical study of the processes of economic growth; the problems of underdeveloped countries; the role of agriculture in a developing economy; an examination of policies and programs needed for effective economic development.

Mr. Maddox.

DEPARTMENT OF AGRICULTURAL EDUCATION

(See School of Education)

DEPARTMENT OF AGRICULTURAL ENGINEERING

Graduate Faculty

Professors: FRANCIS JEFFERSON HASSLER, *Head*, HENRY DITTIMUS BOWEN, GEORGE WALLACE GILES*, WILLIAM ELDON SPLINTER

Professor Emeritus: DAVID S. WEAVER

Associate Professor: JAN VAN SCHILFGAARDE

Assistant Professors: WILLIAM HUGH JOHNSON, KENNETH ALLAN JORDAN, CHARLES WILSON SUGGS

The Department of Agricultural Engineering offers advanced study leading to the Doctor of Philosophy degree in the fields of power and machinery, rural structures, soil and water conservation, rural electrification, and agricultural processing.

* On leave

The Master of Science program in agricultural engineering provides a broad background in science and engineering through advanced study in mathematics and physics. This program provides training in the theoretical and instrumental aspects of engineering research and development as preparation for teaching and research positions with State and Federal institutions and industry.

For those individuals interested primarily in existing technologies, a program of study for the Master of Agricultural Engineering degree permits selections from a variety of advanced application courses. This program provides training for those engaged in the dissemination of information either as extension workers with public institutions or sales and service representatives for industry. This degree is not intended as preliminary study to the Doctor of Philosophy degree.

Admission to full graduate standing requires a bachelor's degree in agricultural engineering from an accredited curriculum or its equivalent.

Unusual opportunities are available for graduate student participation in departmental research programs. The systems approach to operations in crop and animal productions provides a variety of areas within which to define timely investigations.

The department maintains a research shop manned by competent mechanics. The shop is available to graduate students.

Courses for Advanced Undergraduates

AGE 401. Problems in Farm Mechanics 3-0

Prerequisites: AGE 201, 202, Enrollment in Agricultural Education

A study of the mechanical activities engaged in by the vocational agriculture teacher; with emphasis on the role of the teacher in the area of agricultural engineering technology. Included is a study of facilities, equipment, and shop management.
Mr. Howell.

AGE 411. Farm Power and Machinery 11B 3-3

Prerequisite: AGE 211

This course is designed to provide students in Agricultural Engineering Technology with a knowledge of the operations of manufacturing and distributing organizations of farm machinery and their places in these organizations. Included is a practical course in farm tractors and engines with emphasis on familiarizing the student with component parts—their application, operation, and maintenance, as well as with the selection of these units from the standpoint of power, performance, and ratings.

Messrs. Fore, Greene.

AGE 451. Conditioning Principles for Plant and Animal Systems 2-0

Prerequisite: ME 301

Principles of heat transfer and diffusion are presented using the mathematical equations to point out analogous systems. The use of electric analogs to describe thermal and diffusion fields is demonstrated. Psychrometric and heat transfer principles are used to indicate methods of conditioning the environment in agricultural structures. Thin layers drying theory and dimensional analysis are used to describe bulk drying systems of agricultural crops.
Mr. Jordan.

AGE 462. Farm Power and Machinery IIA 4-0

Prerequisites: AGE 211, EM 321

A study of engineering analysis as it applies to problems in the power and

machinery field of Agricultural Engineering. The course is intended to strengthen the students ability to approach agricultural engineering problems in a systematic manner.

Mr. Bowen.

AGE 481. Agricultural Structures as Production Units

0-4

Prerequisites: AGE 451, EM 321

Application of conditioning principles to provide the required environment for optimum agricultural production is stressed. Environment requirements of animals and of harvested crops are discussed. Analysis for labor reduction and the replacement of human decisions with electric controls are indicated. Environmental requirements, proper arrangement, equipment, equipment selection and control, and estimation of external loads are presented to indicate the design procedures for a sound, functional building.

Mr. Jordan.

AGE 491. Rural Electrification

4-0

Prerequisites: EE 320

Wiring and circuitry for both single and three phase applications of electricity to farm and rural community process and operations. A very brief study of the local and regional organization as developed by the electric industries for the dependable generation, transmission, and distribution of power. Electric motor characteristics and selection are studied in the laboratory along with those of water systems, feed grinders and mixers; lighting systems, cooling, ventilating, heating, and the application of switches and controls.

Mr. Weaver.

Courses for Graduates and Advanced Undergraduates

AGE 551. Special Problems

Credits by arrangement

Prerequisite: Senior or Graduate standing in Agricultural Engineering
Each student will select a subject on which he will do research and write technical report on his results. He may choose a subject pertaining to his particular interest in any area of study in Agricultural Engineering.

Mr. Hassler, Staff.

AGE 552. Instrumentation for Agricultural Research and Processing

1-0

Prerequisites: EE 320, MA 301

Elaboration of the theory and principles of various primary sensing elements. Relates the output signal of electrical transducers to wheatstone bridge and potentiometer measuring circuits for calibration of the signal with the variable under study. Introduces the principles of circuits and mechanisms used for indicating, recording, and/or controlling process variables. Representative equipment will be employed whenever feasible.

Mr. Splinter.

Courses for Graduates Only

AGE 651. Research in Agricultural Engineering

Credits by arrangement

Prerequisite: Graduate standing in Agricultural Engineering

A maximum of six credits is allowed toward a Masters degree; no limitation on credits for Doctorate program.

Performance of a particular investigation of concern to Agricultural Engineering. The study will begin with the selection of a problem and culminate with the presentation of a thesis.

Graduate Staff.

AGE 652. Seminar

1-1

Prerequisite: Graduate standing

A maximum of two credits is allowed

Elaboration of the subject areas, techniques and methods peculiar to professional interest through presentations of personal and published works;

opportunity for students to present and defend, critically, ideas, concepts and inferences. Discussions to point up analytical solutions and analogies between problems in Agricultural Engineering and other technologies, and to present the relationship of Agricultural Engineering to the socioeconomic enterprise.

Mr. Hassler.

AGE 654. Agricultural Process Engineering

3-3

Prerequisites: MA 511

Generalized classical thermodynamics is extended by Onsager's relations to provide a theoretical basis for analyzing the energetics of systems that include life processes.

Mr. Johnson.

AGE 661. Analysis of Function and Design of Farm Machinery

3 or 3

Prerequisites: PY 401

Methods and tools used in determining the functional requirements of machine components; writing of machine specifications in terms of fundamental parameters; introduction of the principles of discriminate and indiscriminate mechanical selection of agricultural products with emphasis on the theory of servo-systems.

Mr. Bowen.

AGE 671. Theory of Drainage Irrigation and Erosion Control

4 or 4

Prerequisites: MA 512

Emphasis is placed on the physical and mathematical aspects of problems in conservation engineering and an attempt is made to rationalize procedures which have often come about through experience rather than through analytical considerations. Examples are presented of cases where such an analytical approach has already improved, or shows promise of improving, design criteria and procedures.

Mr. van Schilfgaarde.

AGE 681. Analysis of Function and Design of Farm Buildings

4 or 4

Prerequisites: AGE 481

A study of the functional requirements of farm structures with respect to man, animals and crops and development of the means of providing structures which fulfill the functional requirements. Application of the science and art of engineering in the solution of environmental problems. Advanced planning in the integration of structural environmental design.

Mr. Jordan.

AGRICULTURE

AG 401. Principles and Methods of Extension Education

0-3

A study of the background, development, and operation of the Agricultural Extension Service. Consideration is given to major events leading to the establishment of Agricultural Extension, its objectives, organization, and philosophy. Major emphasis is placed upon the principles underlying Extension education together with methods of programs building and teaching.

Mr. Sloan.

DEPARTMENT OF ANIMAL SCIENCE

Graduate Faculty

Professors: I. D. PORTERFIELD, *Head*, ELLIOTT ROY BARRICK, EDWARD GUY BATTE, GEORGE HYATT, JR., JAMES EDWARD LEGATES, GENNARD MATRONE, W. RAY MURLEY, FRANK HOUSTON SMITH, HAMILTON ARLO STEWART, SAMUEL B. TOVE, LESTER CURTIS ULBERG, GEORGE HERMAN WISE

Professor Emeritus: FRANCIS WEBBER SHERWOOD

Associate Professors: E. U. DILLARD, LEMUEL GOODE, JAMES GIACOMO IECCE,

RICHARD DOUGLAS MOCHRIE, HAROLD ARCH RAMSEY, W. W. G. SMART, JR.,
MILTON B. WISE

Assistant Professors: ALBERT J. CLAWSON, JAMES MURRAY LEATHERWOOD, JOHN
JOSEPH MCNEILL, ODIS WAYNE ROBISON

The Department of Animal Science offers the Master of Science and the Doctor of Philosophy degrees. Programs of training are offered in the fields of animal breeding, animal husbandry, dairy husbandry, animal nutrition, and animal diseases.

Students specializing in animal husbandry may select options in nutrition, physiology and management with beef cattle, sheep and swine. Students in dairy husbandry have options in dairy cattle nutrition, physiology of lactation, rumen physiology, and other phases of dairying.

For students specializing in animal nutrition, work is offered in mineral metabolism, intermediary metabolism, vitamins, rumen microbiology, and other fundamental phases of animal nutrition, involving either laboratory animals or livestock.

Students studying animal diseases are offered specialized work in pathology, parasitology, veterinary bacteriology and virology, and other phases of animal diseases.

Students studying animal breeding may major in physiology of reproduction and quantitative animal genetics, involving livestock and laboratory animals.

In cooperation with other departments, such as the Departments of Poultry, Statistics, Crop Science, Soil Science, Genetics, and Chemistry, specialized subject-matter groups have been developed to direct graduate work in various basic fields. Strong supporting departments in statistics, chemistry and the biological sciences help provide the opportunities for a broad and thorough graduate training.

Animals of various types and breeds, which are available for research, are quartered on approximately 2,000 acres of land operated by the department. In addition, branch stations are located in all major geographic areas of the State so that the research program may be applied to the conditions existing throughout the State. The Animal Industry Central Research Station, located adjacent to the campus, serves as an intermediary between the farms and the laboratories. At this research center, digestion trials, animal disease research, and many phases of the physiology and nutrition programs are conducted. In addition, a physiology of reproduction laboratory and barn, with stalls for 20 bulls and with two temperature control chambers, are used for research in reproduction and in dairy cattle breeding.

The Department of Animal Science, with the exception of the Veterinary Section, is housed in Polk Hall. Research laboratories for animal nutrition, radioactive isotope studies, animal physiology, and animal breeding are located in this building. Other facilities include classrooms, a scientific journal reading room, and offices for the various teaching, research, and extension staff members. A new addition to Polk Hall will aid in meeting the needs for expanded programs. This addition will provide 62,400 square feet of space to be used for research activities, teaching labs, office space, reference rooms, and conference rooms.

The Veterinary Section is located in a modern animal disease laboratory building, which provides excellent facilities for research and teaching in the animal disease field. Included are large animal isolation units for work in the field of veterinary bacteriology and virology, parasitology, physiology, and bacteriology research laboratories and a diagnostic laboratory, and necropsy room.

Every effort is made to provide an opportunity for the graduate student to explore the fundamental principles of animal functions.

Those receiving advanced degrees find employment in other educational and research institutions and in industries servicing the livestock industry or processing livestock products. In the past the demand for well-trained personnel has exceeded the number that has been available.

Courses for Advanced Undergraduates

ANS 404. Dairy Farm Problems

0-3

Prerequisite: ANS 201

Advanced study of practical dairy farm management including farm records, farm buildings, sanitation, roughage utilization and herd culling.

Mr. Murley.

ANS 406. Animal Industry Seminar

0-1

Review and discussion of special topics and the current literature pertaining to all phases of Animal Production.

Mr. Porterfield.

ANS 407. Advanced Livestock Production

0-4

Prerequisites: GN 411, ANS 312

A study of the economic, nutritional, genetic, physiological and managerial factors affecting the operation of commercial and purebred livestock enterprises.

Mr. Barrick.

ANS 408. Reproduction and Lactation

0-3

Prerequisite: ZO 301

Anatomy of the reproductive organs and mammary glands with detailed coverage of the physiological processes involved and of factors controlling and influencing them. A special research problem selected by the student is required.

Messrs. Mochrie, Ulberg.

Courses for Graduates and Advanced Undergraduates

ANS 503. (GN 503) Genetic Improvement of Livestock

3-0

Prerequisite: GN 411

Traits of economic importance in livestock production, and their mode of inheritance. Phenotypic and genetic relationships between traits. The place of selection, inbreeding and cross breeding in a program of animal improvement.

Mr. Robison.

ANS 505. Diseases of Farm Animals

3-0

Prerequisites: CH 101, CH 203; BO 312 desired

The pathology of bacterial, viral, parasitic nutritional, thermal and mechanical disease processes.

Graduate Staff.

ANS 507. Topical Problems in Animal Industry

Max. 6

Special problems may be selected or assigned in various phases of Animal Industry. A maximum of six credits is allowed.

Graduate Staff.

ANS 513. Needs and Utilization of Nutrients by Livestock

0-3

Prerequisite: ANS 312 or equivalent

Measurement of nutrient needs of livestock and the nutrient values of feeds. Nutritive requirements for productive functions.

Mr. Wise.

Courses for Graduates Only

- ANS 600. Research in Animal Industry** Credits by arrangement
A maximum of six hours is allowed toward the Master's degree; no limitation on credits in Doctorate programs. Graduate Staff. **1-1**
- ANS 601. Seminar in Animal Nutrition**
Prerequisite: Permission of seminar leaders
Orientation in philosophy of research, preparation for research and general research methodology. Graduate Staff. **1-1**
- ANS 602. (GN 602) Population Genetics in Animal Improvement** **3-0**
Prerequisites: ST 512, GN 512
A study of the forces influencing gene frequencies, inbreeding and its effects, and alternative breeding plans. Mr. Legates.
- ANS 603. Animal Nutrition: Mineral Metabolism** **3-0**
Prerequisite: CH 551
Principles of mineral metabolism, with emphasis on metabolic functions, reaction mechanisms and interrelationships. Mr. Matrone.
- ANS 604. (ZO 604) Experimental Animal Physiology** **4-0**
Prerequisite: ZO 513 or equivalent
A study of the theories and techniques involved in the use of animals in physiological investigation. Messrs. Ulberg, Wise.
- ANS 614. (BO 614) Bacterial Metabolism** **0-2**
Prerequisites: BO 514 or equivalent and CH 551
The energy metabolism of bacteria; synthesis of carbohydrates, lipids, proteins, purines, pyrimidines, and nucleic acids; bacterial photosynthesis; enzyme formation and metabolic control mechanisms; active transport systems. Mr. McNeill.
- ANS 621. (CH 621) Enzymes and Intermediary Metabolism** **4-0**
Prerequisites: CH 551 and permission of instructor
A study of the properties of enzymes and enzyme action; intermediary metabolism of carbohydrates, lipids, fatty acids, vitamins, and porphyrins; metabolic energy relationships. Mr. Tove.
- ANS 622. (CH 622 and ST 622) Principles of Biological Assays** **0-3**
Prerequisites: CH 551, ST 512
Techniques and designs of biological assays. The interrelationship of logical principles, designs, and analyses is emphasized. Mr. Smart.

DEPARTMENT OF BOTANY AND BACTERIOLOGY

Graduate Faculty

Professors: *HERBERT T. SCOFIELD, *Head*, ERNEST A. BALL, JAMES B. EVANS, LARRY A. WHITFORD

Professor Emeritus: BERTRAM W. WELLS

Associate Professors: ERNEST O. BEAL, JAMES W. HARDIN, JAMES R. TROYER

Assistant Professors: ARTHUR W. COOPER, GERALD H. ELKAN, JOSEPH S. KAHN, HEINZ SELTMANN

The Department of Botany and Bacteriology offers programs leading to the Master of Science degree in the fields of plant physiology, ecology, anatomy, morphology, phycology, systematic botany, and bacteriology. Graduate work in preparation for the doctorate is offered in the fields of plant physiology, morphology, ecology, phycology, systematic botany, and bacteriology.

* On leave until October 31, 1962.

Adequate physical facilities and equipment are available for teaching and research in all phases of the department's program. Outstanding are the laboratory, growth chamber, and greenhouse facilities for research in plant physiology, particularly in mineral nutrition and other phases of experimental plant science. The fine Herbarium supports study in systematics and in ecology. The use of radioisotopes in physiological, phycological, and morphological research is supported with adequate facilities. The availability in the State of a wide range of plant habitats with accompanying diversity in flora provides a setting for numerous research problems in systematics, ecology, and phycology.

Graduate students terminating their work at the master's level have a somewhat limited opportunity as professional botanists or bacteriologists. State, Federal and industrial employment is available as well as academic positions in small colleges and secondary schools. Holders of the Doctor of Philosophy degree will find opportunities for academic positions in colleges and universities, for research positions in Federal and State Experiment Stations, and for research and development work with private industrial or research institutions.

Courses for Advanced Undergraduates

BO 403. Systematic Botany

0-3

Prerequisite: BO 103

A systematic survey of vascular plants emphasizing field identification, terminology, and general evolutionary relationships. Mr. Beal.

BO 412. General Bacteriology

4-0

Prerequisites: CH 107, CH 103, (CH 221 and CH 220 recommended but not required.)

An advanced biology course dealing with bacteria and other microorganisms, their structure, development, and function. Emphasis is placed on the fundamental concepts and techniques in microbiology such as isolation, cultivation, observation, morphology, and the physiology and nutrition of bacteria. The applications of microbiology, the role of microbes in nature, and their role in infection and immunity are considered. Mr. Elkan.

BO 421. Plant Physiology

4-4

Prerequisites: BO 103, 2 courses in chemistry

An introductory treatment of the chemical and physical processes occurring in higher green plants with emphasis upon the mechanisms, factors affecting, correlations between processes, and biological significance.

Messrs. Scofield and Troyer.

BO 441. Plant Ecology

3-0

Prerequisite: BO 103

An introduction to the study of plants in relation to their environment. Major topics considered are: factors of the environment; the structure, analysis, and dynamics of plant communities; past and present distribution of vegetation types. Mr. Cooper.

Courses for Graduates and Advanced Undergraduates

BO 505. Food Microbiology

(See FSP 505)

BO 511. Advanced Bacteriology**0-3**

Prerequisite: BO 412

This course will present the principles and techniques of isolation and characterization of bacteria from a wide range of habitats. Particular stress will be given to the principles of enrichment techniques, differential and selective media, and pertinent diagnostic tests that are applicable to particular groups of bacteria.

Messrs. Evans and Elkan.

BO 512. Morphology of Vascular Plants**3-0**

Prerequisite: BO 103

A study of comparative morphology, ontogeny and evolution of the vascular plants. Emphasis is placed upon the phylogeny of sexual reproduction and of the vascular systems.

Mr. Ball.

BO 513. Plant Anatomy**0-3**

Prerequisite: BO 103

A study of the anatomy of the Angiosperms and Gymnosperms. The development of tissues is traced from their origin by meristems to their mature states.

Mr. Ball.

BO 514. Introductory Bacterial Physiology**3-0**

Prerequisites: BO 412, CH 221, or 220, CH 551 (May be taken concurrently.)

Emphasis will be placed on general principles and function with respect to the living cell. Included will be a study of cell structure, growth, death, reproduction, nutrition, and metabolism. An attempt will be made to illustrate the application of basic principles to applied areas of bacteriology and to other areas of basic science.

Mr. Evans.

****BO 521. Systematic Botany of Monocot Families****3-0**

Prerequisite: BO 403

A comprehensive survey of the systematics and evolution of monocot families. Special emphasis is given to terminology, morphology, identification and relationships.

Mr. Beal.

BO 523. Systematic Botany of Dicot Families*3-0**

Prerequisite: BO 403

A comprehensive survey of the systematics and evolution of dicot families. Special emphasis is given to terminology, morphology, identification and relationships.

Mr. Hardin.

BO 531. Soil Microbiology

(See SOI 532).

BO 534. Physiology of Plant Cells**3-0**

Prerequisite: BO 421 or equivalent. Advanced preparation in chemistry or physics may be substituted with the permission of the instructor.

An advanced treatment of basic plant processes at the cellular level with emphasis on theoretical principles.

Mr. Troyer.

BO 535. Water, Solute and Gas Relations of Plants*0-2**

Prerequisite: BO 534

An advanced treatment of processes of higher plants involving exchange of materials between the plant and its surroundings and movement of materials within the plant. Theoretical principles are emphasized.

Mr. Troyer.

****BO 536. Growth and Development of Plants****0-2**

Prerequisite: BO 534

An advanced treatment of the physiology of growth and development of higher plants, with emphasis on theoretical principles.

Mr. Troyer.

* Offered in 1962-63 and alternate years.

** Offered in 1963-64 and alternate years.

BO 544. Plant Geography*0-3**

Prerequisites: BO 403, 441, GN 411, or equivalents

A course in descriptive and interpretive plant geography, synthesizing data from the fields of ecology, genetics, geography, paleobotany, and taxonomy. The course will include a survey of the present distribution of major vegetation types throughout the world, a discussion of the history and development of this present pattern of vegetation, and a discussion of the principles and theories of plant geography.

Mr. Cooper.

****BO 545. Advanced Plant Ecology****0-3**

Prerequisites: BO 421, 441 or equivalents

An advanced consideration, through class discussions and individual projects, of the principles, theories and methods of plant ecology.

Mr. Cooper.

BO 570. Sanitary Microbiology**0-3**

Fundamental aspects of microbiology and biochemistry are presented and related to problems of stream pollution, refuse disposal and biological treatment. Laboratory exercises present basic microbiological techniques and illustrate from a chemical viewpoint some of the basic microbial aspects of waste disposal.

Mr. Elkan.

BO 574. Phycology**0-3**

Prerequisite: BO 103 or equivalent

A systematic study of the structure and classification of the algae, both fresh-water and marine. The life history and ecology of important local species will be emphasized.

Mr. Whitford.

Courses for Graduates Only**BO 614. Bacterial Metabolism**

(See ANS 614).

BO 620. Advanced Taxonomy**0-3**

Prerequisites: BO 521, 523 or permission of instructor.

A course in the principles of plant taxonomy including the history of taxonomy, systems of classification, rules of nomenclature, taxonomic literature, taxonomic and biosystematic methods, and monographic techniques.

Mr. Hardin.

BO 635. The Mineral Nutrition of Plants**0-3**

Prerequisites: BO 421 and a course in Biochemistry

Discussion of diffusion, molecular specificity and energetics of active transport. The physical chemistry of the essential elements and its significance to their biochemical functions.

Mr. Kahn.

BO 636. Discussions in Plant Physiology**0-1**

Prerequisite: BO 534

Group discussions at an advanced level of selected topics of current interest in plant physiology.

Mr. Troyer.

BO 640. Special Problems in Bacteriology**Credits by arrangement**

Directed research in some specialized phase of bacteriology other than a thesis problem but designed to provide experience and training in research.

Graduate Staff.

BO 641. Research in Bacteriology**Credits by arrangement**

Original research preparatory to writing a master's thesis or a Ph.D. dissertation.

Graduate Staff.

* Offered in 1962-63 and alternate years.

** Offered in 1963-64 and alternate years.

BO 650. Special Problems in Botany**Credits by arrangement**

Directed research in some specialized phase of botany other than a thesis problem but designed to provide experience and training in research.

Graduate Staff.

BO 651. Research in Botany**Credits by arrangement**

Original research preparatory to writing a master's thesis or a Ph.D. dissertation.

Graduate Staff.

BO 660. Bacteriology Seminar**1-1**

Scientific articles, progress reports in research, and special problems of interest to bacteriologists are reviewed and discussed. Graduate student credit allowed if one paper per semester is presented at seminar.

Graduate Staff.

BO 661. Botany Seminar**1-1**

Scientific articles, progress reports in research, and special problems of interest to botanists are reviewed and discussed. Graduate student credit is allowed if one paper per semester is presented at seminar.

Graduate Staff.

CERAMIC ENGINEERING**See Department of Mineral Industries****DEPARTMENT OF CHEMICAL ENGINEERING****Graduate Faculty**

Professors: EDWARD MARTIN SCHOENBORN, *Head*, JAMES K. FERRELL, KENNETH ORION BEATTY, JR.

Associate Professors: RICHARD BRIGHT, JOHN FRANK SEELY

Assistant Professor: DAVID B. MARSLAND

The Department of Chemical Engineering offers programs of advanced study and research leading to the Master of Science and Doctor of Philosophy degrees. The chemical engineering faculty seeks to provide a close association between faculty and students, to promote a common interest in advanced professional study, and to encourage intensive investigation, and top-level creative activity.

Graduate work in chemical engineering is of increasing importance since it enables the student to attain a higher degree of specialized professional competence and at the same time to secure greater mastery of the sciences which underlie the quantitative aspects of chemical technology. The demand for chemical engineers with advanced training is greater now than at any time since the beginning of the chemical industry. The number and variety of challenging opportunities are steadily increasing, especially in the South which is rapidly becoming the new industrial frontier. The recent high concentration of industries producing synthetic fibers and other materials within a radius of several hundred miles of the State College is one example of this development.

Students having had one or more years of training beyond the baccalaureate are especially needed for fundamental and applied research, for process development and design, for production, and even for management, technical services and sales. Private consulting work and careers in teaching usually demand a period of advanced study well beyond the normal four-year undergraduate program.

At present, major emphasis in the department is concerned with basic studies of unit operations such as fluid flow, heat transfer at high and low temperatures, distillation, solvent extraction, etc., with thermodynamics, reaction kinetics, phase equilibria, plastics technology, process measurement and control, and many other aspects of chemical technology. A new laboratory devoted exclusively to the study of thermal properties of materials provides unique facilities for graduate work in this field. Strong supporting programs of work are also available in mathematics, statistics, physics, chemistry, nuclear engineering, metallurgy, the life sciences, textiles, and other fields of engineering.

The Department of Chemical Engineering occupies the four-story east wing of the Riddick Engineering Laboratories building. Modern, well-equipped laboratories are provided with all necessary services for both teaching and research. A wide variety of special facilities such as X-ray equipment, spectrophotometers, electron microscope, electro-mechanical testing machine, electronic controllers and recorders, etc., are available for graduate research.

In cooperation with the Department of Engineering Research, members of the chemical engineering staff conduct a number of important research projects which are supported by industry, and by State and governmental agencies. Graduate students assisting on these projects not only acquire financial assistance but gain valuable research experience on problems of current interest.

In addition to research assistantships, the department also offers each year a limited number of graduate assistantships for part-time work in the department. These may be for teaching, laboratory preparation, etc., or for research, as the needs arise. Appointments are for one academic year of nine months for half-time work and at the present carry a stipend of \$2,400. They are renewable upon evidence of satisfactory performance.

Courses for Advanced Undergraduates

CHE 411. Unit Operations I

Required of Juniors in Chemical Engineering

Prerequisites: MA 202, PY 202

Principles of fluid flow, heat transfer, evaporation, etc., with emphasis on design calculations.

CHE 412. Unit Operations II

4-0

Required of Seniors in Chemical Engineering

Prerequisite: CHE 411

A continuation of CHE 411 with emphasis on the diffusional operations such as absorption, distillation, extraction, drying, etc.

CHE 415. Chemical Engineering Thermodynamics

4-0

Required of Juniors in Chemical Engineering

Prerequisite: CHE 311

A study of the laws of thermodynamics and their application to chemical engineering problems. Emphasis on the theory, data and approximation methods as applied to physical and chemical systems.

CHE 421, 422. Reactor Energy Transfer

3-3

Prerequisites: MA 202, PY 202

Thermodynamics, heat transfer and fluid flow with emphasis on the problems and methods used in the design and analysis of nuclear reactors.

Mr. Ferrell.

CHE 431, 432. Unit Operations Laboratory I and II **3-3**
 Required of Seniors in Chemical Engineering
 Prerequisite: CHE 411

Laboratory work on typical apparatus involving the unit operations. Experiments are designed to augment the theory and data of the lecture courses and to develop proficiency in the writing of technical reports.

CHE 453. Chemical Processing of Radioactive Materials **3 or 3**
 Consideration of the unique procedures required for the bulk manipulation of radioactive chemicals. Particular attention is given to remote operational procedures of precipitation, centrifugation, conveying, solvent extraction and ion exchange. Design of apparatus involving low maintenance and ease of replacement and cleaning by safe methods is considered. Other topics include decontamination procedures in disposal of wastes.

CHE 460. Seminar **1 or 1**
 One semester required of Seniors in Chemical Engineering
 Literature survey of selected topics in chemical engineering. Emphasis on written and oral presentation.

CHE 470. Chemical Engineering Projects **2 or 2**
 Introduction to research through experimental, theoretical and literature studies of chemical engineering problems. Oral and written presentation of reports.

Courses for Graduates and Advanced Undergraduates

CHE 525. Process Measurement and Control **3 or 3**
 Prerequisite: CHE 411

Theory and application of methods for measuring, transmitting, recording and controlling such process variables as temperature, pressure, flow rate, liquid level, concentration, humidity, etc. Commercial instruments are utilized for study of a wide variety of industrial control problems. Recorder-controllers are available for simulating industrial control problems of varying difficulty. Mr. Seely.

CHE 527. Chemical Process Engineering **0-3**
 Prerequisite: CHE 412

A study of selected chemical processes with emphasis on the engineering, chemical and economic factors involved. Mr. Marsland.

CHE 540. Electrochemical Engineering **3 or 3**
 Prerequisite: Physical Chemistry

The application of electrochemical principles to such topics as electrolysis, electroanalysis, electroplating, metal refining, etc. Mr. Schoenborn.

CHE 541. Cellulose Industries **3 or 3**
 Prerequisite: Organic Chemistry

Methods of manufacture and application of cellulose chemical conversion products. Emphasis placed on recent developments in the field of synthetic fibers, films, lacquers, and other cellulose compounds. Mr. Seely.

CHE 542. Technology of Pulp and Paper **3 or 3**
 Prerequisite: Organic Chemistry

Fundamentals of pulp and paper manufacture with emphasis on recent advances in the field. One laboratory period per week is devoted to topics such as digestion and treatment of pulp, hardsheet preparation and testing, fiber analysis, and chemical and physical tests. Mr. Seely.

CHE 543. Technology of Plastics **3 or 3**
 Prerequisite: Organic Chemistry

The properties, methods of manufacture, and applications of synthetic resins. Recent developments in the field are stressed. Mr. Seely.

CHE 545. Petroleum Refinery Engineering**3 or 3**

Prerequisite: CHE 412

An introduction to the petroleum industry including (1) nature of petroleum and its fractions, octane numbers, viscosity relationships, etc., (2) operations of thermal and catalytic cracking, stabilization, alkylation, isomerization, crude fractionation, etc., (3) problem work covering high pressure relationships, and related material.

Graduate Staff.

CHE 546. Chemical Reaction Rates**3 or 3**

Prerequisite: CHE 415

A basic study of the rates of homogeneous reactions, heterogeneous reactions, and catalysis.

Mr. Stahel.

CHE 551. Thermal Problems in Nuclear Engineering**3 or 3**

Prerequisites: ME 302 or 303; or CHE 411; or equivalent

The design and operation of nuclear reactors and the utilization of the power from them involves major problems in nearly every phase of heat transfer, and many important problems in fluid flow. Possible solutions to these problems are severely affected by the influences of radiation on heat transfer media, hazards of handling radioactive substances, etc. The course considers the thermal problems of nuclear reactor design and the principles of fluid flow and heat transfer necessary to their solutions.

The course is intended for engineers and science students with backgrounds in physics and mathematics and elementary thermodynamics.

Mr. Beatty.

CHE 553. Separation Processes in Nuclear Engineering**3 or 3**

Prerequisite: CHE 412 or equivalent

A study of the principles and techniques of separation and purification of chemical components, based upon mass transfer by diffusion. Specific techniques covered are distillation, extraction, adsorption and ion exchange, particularly in regard to continuous, counter-current operations. Special topics include a survey of fuel processing, technology of uranium processing, complexing action of solvents, and halide distillation.

The course is primarily intended for engineers and science students with backgrounds in mathematics, physics and elementary chemistry but who have had no previous course in separation processes.

Mr. Beatty.

CHE 570. Chemical Engineering Projects**1 to 3 credits**

Prerequisite or concurrent: CHE 412

A laboratory study of some phase of chemical engineering or allied field.

Graduate Staff.

Courses for Graduates Only**CHE 610. Heat Transfer I****3 or 3**

Prerequisite: CHE 411

An advanced course dealing primarily with heat transfer between liquids and solids, optimum operating conditions and design of equipment, conduction, heating and cooling of solids, radiant heat transmission.

Mr. Beatty.

CHE 611. Heat Transfer II**2 or 2**

Prerequisite: CHE 610

An intensive study of recent advances in heat transfer and allied fields.

Mr. Beatty.

CHE 612. Diffusional Operations**3 or 3**

Prerequisite: CHE 412

An advanced treatment of mass transfer particularly as applied to absorption, extraction, drying, humidification and dehumidification.

Mr. Schoenborn.

CHE 613. Distillation**3 or 3**

Prerequisite: CHE 412

Vapor-liquid equilibria of non-ideal solutions, continuous distillation of binary and multicomponent systems, batch distillation, azeotropic and extractive distillation.

Mr. Schoenborn.

CHE 614. Drying of Solids**2 or 2**

Prerequisite: CHE 412

An advanced course on the mechanism of drying operations with application to design of equipment, such as cabinet, tunnel, rotary, drum and spray driers.

Mr. Marsland.

CHE 615. Thermodynamics I**3 or 3**

Prerequisite: CHE 415

Advanced topics in chemical engineering thermodynamics including equilibria of physical and chemical systems, high pressure systems, generalized properties of hydrocarbon, etc.

Mr. Beatty.

CHE 616. Thermodynamics II**2 or 2**

Prerequisite: CHE 615

An intensive study of recent advances in thermodynamics.

Mr. Beatty.

CHE 617. Catalysis of Industrial Reaction**3 or 3**

Prerequisite: CHE 546

A study of the mechanism of catalysis with emphasis on practical application to operation and design of industrial processes.

Mr. Stahel.

CHE 631, 632. Chemical Process Design**3-3**

Prerequisite: CHE 412

Design and selection of process equipment, through solution of comprehensive problems involving unit operations, kinetics, thermodynamics, strength of materials and chemistry.

Graduate Staff.

CHE 641, 642. Advanced Chemical Engineering Laboratory**2-2**

Prerequisite: CHE 412

Advanced laboratory work in a selected field with emphasis on theory, techniques and performance of equipment.

Graduate Staff.

CHE 650. Advanced Topics in Chemical Engineering**1 to 3 credits
per semester**

A study of recent development in chemical engineering theory and practice, such as ion exchange, crystallization, mixing, molecular distillation, hydrogenation, fluorination, etc. The topic will vary from term to term.

Graduate Staff.

CHE 660. Chemical Engineering Seminar**1 credit per semester**

Literature investigations and reports of special topics in chemical engineering and allied fields.

Graduate Staff.

CHE 680. Chemical Engineering Research**Credits by arrangement**

Independent investigation of an advanced chemical engineering problem. A report of such an investigation is required as a graduate thesis.

Graduate Staff.

DEPARTMENT OF CHEMISTRY**Graduate Faculty**

Professors: RALPH CLAY SWANN, *Head*, THOMAS GLENN BOWERY, GEORGE OSMORE DOAK, RICHARD HENRY LOEPPERT, WALTER JOHN PETERSON, WILLIS ALTON REID, COWIN COOK ROBINSON, PAUL PORTER SUTTON, JOSEPH ARTHUR WEYBREW

Associate Professors: ALONZO FREEMAN COOTS, LEON DAVID FREEDMAN,

FORREST WILLIAM GETZEN, LOUIS ALLMAN JONES, RICHARD COLEMAN PINKERTON, EDWARD C. SISLER, SAMUEL B. TOVE, RAYMOND CYRUS WHITE
Assistant Professor: GEORGE GILBERT LONG

The Department of Chemistry offers the degree of Master of Science in chemistry. Before the master's program is initiated, a student must have met the requirements set forth by the Committee on Professional Training of the American Chemical Society for the baccalaureate degree, either at the institution in which he received his undergraduate training or at North Carolina State College. The minimum course requirements in chemistry for the bachelor's degree consist of four basic year courses in general inorganic chemistry, analytical chemistry, physical chemistry, and organic chemistry, and one semester of inorganic chemistry, together with at least two advanced courses. Mathematics, comprising the equivalent of two years of college work, which must include one year of differential and integral calculus and differential equations, is also required.

Instruction in chemistry trains students in all areas of chemistry, strongly supported with fundamental training in physics and mathematics. Educational, commercial, and research positions are open to men and women trained in the chemistry of plants, animals, soils, fertilizers, insecticides, foods and feeds, vitamins and nutrition, and clinical and biophysical chemistry. In the past, the majority of graduates with the Master of Science degree have continued their education toward the Doctor of Philosophy degree with a major in one of the branches of chemistry.

The Department of Chemistry is adequately equipped with standard instruments and apparatus available for both teaching and research. A sizeable assortment of specialized equipment is also available. Much of this equipment is the most modern and versatile available and hence suitable for fundamental investigations. Included are substantial facilities in: radiochemistry—gamma spectrometer, proportional counters, Geiger counters, neutron source, etc.; spectroscopy—double grating infra-red spectrometer, far ultraviolet-ultra-violet-visible-near infrared absorption spectrophotometer, grating emission spectrograph, photofluorimeter, etc.; electrochemistry—coulometer, controlled potential electro-deposition apparatus, polarograph, conductivity bridges, oscillogram, etc.; organic chemistry—high pressure reactors, precision refractometer, polarimeter, fractionating columns, controlled atmosphere box, etc.

A shop equipped with standard power tools (drill press, lathes, band saws, etc.) is available to research workers for construction of special apparatus. Glass-blowing facilities are also available.

Complete sets of reference works of more than one hundred chemical (including biochemical and nutritional) journals in English, German, and French are accessible for student use in the D. H. Hill Library. Current numbers of the most widely used chemical journals (including all of those published by the American Chemical Society) are available in the Chemistry Library.

Some of the areas of specialization for research studies available include: kinetics of gas phase reaction; problems in electro chemistry; distribution and structure of the flavin enzymes; charged particle cross section measurements; application of radiotracer techniques to physical chemistry problems;

research in fission product analysis, neutron activation and nuclear thermodynamics; synthesis and properties of organophosphorus and organoarsenic compounds; kinetics of inorganic reactions; relation of chemical structure to herbicidal properties; problems in infra-red and ultra-violet spectroscopy; problems in solid state chemistry; vitamin methodology; nutritional requirements to various farm animals (in cooperation with the Nutrition Section, Animal Science Department) mechanisms involved in plant physiological processes; techniques of spectrographic analysis and their application in research with plants, soils, and animals; and preparation and characterization of fat acid esters and derived products.

Courses for Advanced Undergraduates

CH 411. Analytical Chemistry I

0-4

Prerequisites: CH 431, 432 (Coreq. CH 433, 434)

An introduction to analytical chemistry including both classical and modern techniques involving the distribution of a component between phases; for example, gravimetric methods, gas chromatography and adsorption.

Messrs. Long and Pinkerton.

CH 413. Analytical Chemistry II

4-0

Prerequisite: CH 411

A continuation of analytical chemistry I with emphasis upon modern approaches to acid-base chemistry, oxidation-reduction, potentiometric methods, and spectrophotometry.

Messrs. Long and Pinkerton.

CH 420. Organic Preparations

0-3

Prerequisites: 3 yrs. chemistry including CH 223

Experiments selected to acquaint the student with advanced methods and techniques in the preparation of organic substances.

Messrs. Doak and Freedman.

CH 431-433. Physical Chemistry I and II

3-3

Prerequisites: CH 107, MA 202 and PY 202

An intensive study of the states of matter, solutions, colloids, homogeneous and heterogeneous equilibrium, reaction kinetics, electrolysis, conductance, oxidation reactions, ionic equilibrium.

Messrs. Getzen, Bowen, and Sutton.

CH 432-434. Physical Chemistry Laboratories

1-1

Prerequisites: (Coreq. CH 431 and CH 433)

Laboratory courses to accompany lecture work in Physical Chemistry I and II respectively.

Graduate Staff.

CH 435. Physical Chemistry III

3-0

Prerequisite: CH 433

An intensive study of the structure of atoms and molecules, an introduction to statistics, and selected topics in modern physical chemistry.

Graduate Staff.

CH 441. Colloid Chemistry

0-3

Prerequisites: CH 220 and CH 215

Adsorption, preparation, properties, constitution, stability and application of sols, gels, emulsions, foams, and aerosols; dialysis, Donnan membrane equilibrium.

Mr. Getzen.

CH 491. Reading in Honors Chemistry

Credits by arrangement

A reading course for exceptionally able students at the senior level. The students will do extensive reading in areas of advanced chemistry and will present written reports of their findings.

Graduate Staff.

Courses for Graduates and Advanced Undergraduates

CH 501. Inorganic Chemistry I

3-0

Prerequisite: CH 433

Modern inorganic chemistry from the point of view of the chemical bond. Topics covered are: chemical periodicity and its origins in atomic structure; the ionic bond and electroegativity; crystal structure and bonding in ionic solids; the metallic state, conduction and semiconductors; the preparation and properties of illustrative compounds.

Mr. Pinkerton.

CH 503. Inorganic Chemistry II

0-3

Prerequisite: CH 501

A continuation of CH 501. Topics covered are: the hydrogen molecule-ion and the theory of the covalent bond; molecular orbitals and hybridization; dipole moments and magnetic properties; the theory of acids and bases; non-aqueous solvents; co-ordination compounds, carbonyls and quasi-aromatic compounds; and the chemistry of the transition metals, lanthanides and actinides.

Mr. Long.

CH 511. Chemical Spectroscopy

3-0

Prerequisite: CH 433

Theory, analytical applications and interpretation of spectra as applied to chemical problems. Major emphasis will be placed upon ultraviolet, visible and infrared spectra.

Mr. Long.

CH 512. (TC 512) Chemistry of High Polymers

3-0 or 0-3

CH 513. Electroanalytical Chemistry

0-3

Prerequisite: CH 413

A course in electroanalytical chemistry including the foundations of theoretical electrochemistry. Topics covered are: Potentiometric measurements and electrical resistance; diffusion, transport; theory of dilute solutions: polarography and amperometric measurements; surface effects and electrode kinetics; electrochemistry in non-aqueous systems.

Mr. Pinkerton.

CH 521. Advanced Organic Chemistry I

3-0

Prerequisites: 3 yrs. chemistry including CH 223

Resonance reaction mechanisms; hydrocarbons, organic halides, alcohols, amines, and carbonyl compounds.

Mr. Doak.

CH 523. Advanced Organic Chemistry II

0-3

Prerequisite: CH 521

Stereochemistry, steroids and other natural products organometallics and heterocycles.

Mr. Doak.

CH 525. Physical Organic Chemistry

0-3

Prerequisites: CH 223 and CH 433

Theoretical and physical aspects of organic chemistry; structure and mechanism in organic chemistry.

Mr. Loeppert.

CH 527. Chemistry of Metal-Organic Compounds

3-0

Prerequisites: 3 yrs. chemistry including CH 223

A study of the preparation, properties and reactions of compounds containing the carbon-metal bond, with a brief description of their uses.

Mr. Doak.

CH 528. Qualitative Organic Analysis

4-0

Prerequisites: 3 yrs. chemistry including CH 223

A study of class reactions, functional groups, separation, identification and preparation of derivatives.

Mr. Doak.

CH 529. Quantitative Organic Analysis

0-3

Prerequisites: CH 223 and CH 411

Quantitative determination of carbon, hydrogen, nitrogen, halogens, sulfur and various functional groups in organic materials, with emphasis on semimicro methods.

Graduate Staff.

CH 531. Chemical Thermodynamics**3-0**

Prerequisites: CH 433 and MA 301

An extension of elementary principles to the treatment of ideal and real gases, ideal solutions, electrolytic solutions, galvanic cells, surface systems, and irreversible processes. An introduction to statistical thermodynamics and the estimation of thermodynamic functions from spectroscopic data.

Mr. Sutton.

CH 533. Chemical Kinetics**0-3**

Prerequisites: CH 433 and MA 301

An intensive survey of the basic principles of chemical kinetics with emphasis on experimental and mathematical techniques, elements of the kinetic theory, and theory of the transition state. Applications to gas reactions, reactions in solution, and mechanism studies.

Mr. Bowen.

CH 535. Surface Phenomena**3-0**

Prerequisites: CH 433 and MA 301

An intensive survey of the topics of current interest in surface phenomena. This course is designed to cover the foundations of the present understanding of surface behavior. Formulation of basic theories are presented together with illustrations of their current applications.

Mr. Getzen.

CH 537. Quantum Chemistry**0-3**

Prerequisites: CH 435, PY 401 and PY 407

The elements of wave mechanics applied to stationary energy states and time-dependent phenomena. Applications of quantum theory to chemistry, particularly chemical bonds.

Mr. Coots.

CH 543. Radioisotope Principles**3-0**

Prerequisites: CH 433, PY 202 and MA 202

A presentation of the basic knowledge of radioactivity, nuclear reactions, ionizing radiations, and radiochemistry essential to competence in the use of radioisotopes.

Mr. Coots.

CH 544. Radioisotope Techniques**1-0**

Prerequisites: (Coreq. CH 543)

A laboratory course in the physical and chemical techniques essential to competence in the use of radioisotopes.

Mr. Coots.

CH 545. Radiochemistry**0-3**

Prerequisites: CH 543, or PY 407 and PY 410

An advanced presentation of the applications of radioactivity to chemistry and of the applications of chemistry to the radioactive elements, particularly the heavy elements and fission products.

Mr. Coots.

CH 546. Radiochemistry Laboratory**0-1**

Prerequisite: (Coreq. CH 545)

The laboratory work associated with CH 545 Radiochemistry.

Mr. Coots.

CH 551. General Biological Chemistry**5-0**

Prerequisites: 3 yrs. chemistry including CH 223

The chemical constitution of living matter. Biochemical processes as well as compounds are studied.

Mr. Peterson.

CH 553. Chemistry of Proteins and Nucleic Acids**0-3**

Prerequisites: CH 551

Composition, distribution, structure, properties and metabolism of amino acids, proteins, and nucleic acids.

Mr. Armstrong.

CH 555. Plant Chemistry**0-3**

Prerequisite: CH 551

Composition of plants, properties, nature, and classification of plant constituents, changes occurring during growth, ripening and storage of plant products.

Mr. Sisler.

Courses for Graduates Only

- CH 621. (ANS 621) Enzymes and Intermediary Metabolism** **4-0**
 Prerequisite: CH 551
 A study of the properties of enzymes and enzyme action, intermediary metabolism of carbohydrates, amino acids, fatty acids, vitamins, purines and porphyrins, metabolic energy relationships. Mr. Tove.
- CH 622. (ANS 622) Principles of Biological Assays** **0-3**
 Prerequisites: CH 551 or ANS 312 and ST 512
 Techniques and designs of biological assays for vitamins; interrelationships of logical principles, design, and analysis is emphasized. Mr. Smart.
- CH 631. Chemical Research** **Credits by arrangement**
 Prerequisites: 40 semester credits in chemistry. Open to all graduates.
 Special problems that will furnish material for a thesis. A maximum of 6 semester credits is allowed toward a Master's degree, no limitation on credits in Doctorate programs. Graduate Staff.
- CH 641. Seminar** **Credits by arrangements**
 Prerequisites: Graduate standing in Chemistry.
 Required of graduate students specializing in Chemistry.
 Scientific articles, progress reports in research, and special problems of interest to chemists are reviewed and discussed.
 A maximum of two semester credits is allowed toward the Master's degree, but any number toward the Doctorate. Graduate Staff.
- CH 651. Special Topics in Chemistry** **Maximum 3 credits**
 Prerequisite: Graduate standing in Chemistry
 Critical study of some special problems in one of the branches of Chemistry involving original investigation together with a survey of pertinent literature. Graduate Staff.
- CH 671. Advanced Physical Chemistry** **3-0**
 Prerequisite: CH 533
 Involves a thorough review of the fundamental principles of physical chemistry with extension and application of these to the study of solid state. Mr. Sutton.
- CH 672. Advanced Physical Chemistry** **0-3**
 Prerequisite: CH 671
 There will be laid down the elements of statistical mechanics and Kinetic theory, in terms of which certain topics from CH 671 will be more exhaustively developed. Mr. Sutton.

DEPARTMENT OF CIVIL ENGINEERING

Graduate Faculty

Professors: CHARLES RAYMOND BRAMER, RALPH EIGIL FADUM, CHARLES RUSSELL McCULLOUGH, CARROL LAMB MANN, JR., CHARLES SMALLWOOD, JR.,
Graduate Administrator, MEHMET ENSAR UYANIK
Associate Professors: *RICHARD HUGH BIGELOW, PAUL DAY CRIBBINS, JOHN WILLIAM HORN, PAUL Z. T. ZIA
Assistant Professor: MICHAEL AMEIN

The Department of Civil Engineering offers programs of study leading to Master of Science and Doctor of Philosophy degrees. Graduate course work is available in the fields of sanitary engineering, soil mechanics and foundation engineering, structural engineering, and transportation engineering.

* On leave, 1961-62

Whereas the Master of Science program would normally include course work in only one of these specialty fields, a program of study leading to the Doctor of Philosophy degree would encompass course work in a related combination of these fields.

Laboratory facilities for sanitary engineering research work include an hydraulics laboratory, a chemical laboratory, and a biological laboratory.

For work in soil mechanics and foundation engineering, a fully-equipped laboratory with modern soil-testing equipment is available.

Facilities for structural engineering research include a well-equipped physical testing laboratory and in addition an air-conditioned structural models laboratory.

Transportation engineering facilities are a bituminous laboratory, an airphoto interpretation laboratory, a photogrammetry laboratory, and a traffic engineering laboratory provided with traffic control devices.

In addition to these facilities, equipment for research is made available by the Department of Engineering Research.

Some unique opportunities for research are offered the graduate student in civil engineering by reason of the location of North Carolina State College in the State's Capital City. There are a number of cooperative research endeavors with municipal and State governmental agencies that provide funds for research assistantships.

The resources of the institution also provide unique opportunities for combining studies in civil engineering with studies in other related fields.

In recognition of the need by industry for personnel with training in water supply and the abatement of water pollution, the Civil Engineering Department suggests that students in the many curricula leading to positions in industry (food processing, textile chemistry, pulp and paper technology, chemical engineering, zoology and others) consider courses of instruction in sanitary engineering for advanced undergraduate electives, and minor sequences for advanced degrees. Among the courses appropriate for such students are the following: CE 482, Water and Sewage Works; CE 571, Theory of Water and Sewage Treatment; CE 573, Analysis of Water and Sewage; CE 673, Industrial Water Supply and Waste Disposal; and CE 674, Stream Sanitation.

There exists a growing need for the coordination of transportation facilities and land planning and for individuals with competence in both fields. To fulfill this need, an advanced program leading to a post-baccalaureate degree in engineering, majoring in transportation engineering, and to the degree of Master of Regional Engineering at North Carolina State College and the Department of City and Regional Planning at the University of North Carolina. Qualified students have the opportunity to schedule their courses of instruction to enable them to qualify for both advanced degrees.

The program is designed for students who are desirous of becoming technically proficient in both the fields of transportation engineering and city and regional planning. The minimum residence requirements include two academic years plus a summer internship. The curriculum includes the major core courses for both the advanced transportation engineering program and the city and regional planning program, plus supplementary courses important to both endeavors and a thesis. A bachelor's degree in engineering, including a knowledge of transportation engineering, from an

institution of recognized standing is required for admission to the program. Applicants who do not meet these requirements in full may submit their credentials for examination and consideration.

Further information concerning the joint program may be obtained from the Department of Civil Engineering at North Carolina State College or from the Department of City and Regional Planning at the University of North Carolina.

Courses for Advanced Undergraduates

- CE 425. Structural Analysis II** **3-0**
 Prerequisites: CE 324 and EM 321
 Required of seniors in Civil Engineering
 Deflection of beams and trusses; indeterminate stress analysis by moment area, slope deflection and moment distribution.
- CE 427. Structural Design I** **4-0**
 Prerequisites: CE 324 and EM 321
 Required of seniors in Civil Engineering and Civil Engineering Construction Option
 Analysis and design of reinforced concrete building elements; design of tension, compression and simple flexural members of steel and of timber.
- CE 428. Structural Design II** **0-3**
 Prerequisites: CE 425 and CE 427
 Required of seniors in Civil Engineering
 Design specifications; connection details; independent and complete design of engineering structures.
- CE 429. Elements of Structural Design II** **0-3**
 Prerequisite: CE 427
 Required of seniors in Civil Engineering Construction Option
 Design of tension, compression and flexural elements of steel and timber; solution of problems in erection, forms, shoring and falsework.
- CE 442. Soil Mechanics** **3-0**
 Prerequisite: CE 305
 Required of seniors in Civil Engineering
 Fundamental stress relations, Mohr's rupture hypothesis, shearing strength, earth pressure theories, bearing capacity, stability of slopes, hydrostatics, and hydrodynamics of ground water.
- CE 443. Foundations** **0-3**
 Prerequisite: CE 427
 Required of seniors in Civil Engineering Construction Option
 Identification and classification of soils; geological aspects of foundation engineering; methods of investigating subsoil conditions; control of water; types of foundations and conditions favoring their use; legal aspects of foundation engineering.
- CE 461. Project Planning and Control I** **3-0**
 Prerequisite: CE 362
 Required of seniors in Civil Engineering Construction Option
 Analysis of construction plant layout requirements and performance characteristics of equipment.
- CE 462. Project Planning and Control II** **0-3**
 Prerequisite: CE 461
 Required of seniors in Civil Engineering Construction Option
 Scheduling, analysis and control of construction projects.

- CE 464. Legal Aspects of Contracting** **0-3**
 Prerequisite: Senior standing
 Required of seniors in Civil Engineering Construction Option; elective
 Legal aspects of construction contract documents and specifications; owner-engineer-contractor relationships and responsibilities; bids and contract performance; labor laws.
- CE 481. Hydrology and Drainage** **2-0**
 Prerequisite: CE 382
 Required of seniors in Civil Engineering
 Occurrence and distribution of rainfall; runoff, surface and ground waters; design of drainage and control structures.
- CE 482. Water and Sewage Works** **0-3**
 Prerequisite: Senior standing
 Required of seniors in Civil Engineering
 Water supply analysis and design, including population estimates, consumption, source selection, aqueducts, distribution systems and pumping stations; elements of water treatment; collection and disposal of sewage; elements of sewage treatment.
- CE 485. Elements of Hydraulics and Hydrology** **3-0**
 Prerequisite: EM 312
 Required of seniors in Civil Engineering Construction Option
 Elements of fluid mechanics, hydraulics and hydrology, with application to problems in construction engineering.
- CE 492, 493. Professional Practice I, II** **1-1**
 Prerequisite: Senior standing
 Required of seniors in Civil Engineering and Civil Engineering Construction Option
 Professional engineering societies and their functions; professional standards; topics of current interest to the civil engineer.

Courses for Graduates and Advanced Undergraduates

- CE 507. Airphoto Analysis I** **3-0**
 Prerequisite: Junior standing
 Engineering evaluation of aerial photographs, including analysis of soils and surface drainage characteristics. Mr. McCullough.
- CE 508. Airphoto Analysis II** **0-3**
 Prerequisite: CE 507
 Engineering evaluation of aerial photographs for highway and airport projects. Mr. McCullough.
- CE 509. Photogrammetry** **3 or 3**
 Prerequisite: CE 201
 Elements of photogrammetry as applied to surveying and mapping. Aerial and terrestrial photogrammetry. Flight planning and ground controls. Stereoscopes and stereoscopic plotting instruments. Measurements on photographs. Graduate Staff.
- CE 510. Advanced Surveying** **3 or 3**
 Prerequisite: CE 202
 State coordinate systems and map projections. Elements of geodetic and astronomical surveying. Adjustment of observations by the method of least squares. Graduate Staff.
- CE 514. Municipal Engineering Projects** **0-3**
 Prerequisite: Senior standing
 Special problems relating to public works, public utilities, urban planning and city engineering. Messrs. Horn, Smallwood.

- CE 515. Transportation Operations** **3-0**
 Prerequisite: CE 306
 The analysis of traffic and transportation engineering operations.
 Messrs. Cribbins, Horn.
- CE 516. Transportation Design** **3 or 3**
 Prerequisite: CE 306
 The geometric elements of traffic and transportation engineering design.
 Messrs. Cribbins, Horn.
- CE 524. Analysis and Design of Masonary Structures** **3-0**
 Corequisite: CE 425
 Analysis and design of arches, culverts, dams, foundations and retaining walls.
 Mr. Bramer.
- CE 525, 526. Advanced Structural Analysis I, II** **3-3**
 Prerequisite: CE 425
 Analysis of rigid frames and continuous structures; treatment of redundant members and secondary stresses.
 Mr. Bramer.
- CE 527. Numerical Methods in Structural Analysis** **0-3**
 Prerequisite: CE 425
 Newmark's numerical integration procedure and its applications; matrix operations, relaxation and iteration, finite difference method. Force and displacement methods, string polygon method. High-speed computation.
 Messrs. Bigelow, Zia.
- CE 531. Experimental Stress Analysis** **3-0**
 Prerequisite: CE 425
 Principles and methods of experimental analysis; dimensional analysis; applications to full-scale structures.
 Mr. Bramer.
- CE 532. Structural Laboratory** **0-3**
 Prerequisite: CE 425
 Test procedures and limitations and interpretation of experimental results.
- CE 534. Plastic Analysis and Design** **0-3**
 Prerequisite: CE 427
 Analysis of steel structure behavior beyond the elastic limit; concept of design for ultimate load and the use of load factors. Analysis and design of component parts of frames. Methods of predicting strength and deformation behavior of structures loaded in the plastic range. Bracing and connecting requirements for frame.
 Mr. Bramer.
- CE 535. Ultimate Strength Theory and Design** **3-0**
 Prerequisite: CE 427
 Ultimate strength theories of axially loaded column, flexure, combined flexure and axial load, shear. Critical review of important research and their relationship with the development of design codes for reinforced concrete.
 Mr. Zia.
- CE 536. Theory and Design of Prestressed Concrete** **0-3**
 Prerequisite: CE 427
 The principles of prestressed concrete. Materials. Methods of prestressing. Loss of prestress. Design of beams for bending, shear and bond. Ultimate strength. Deflection. Composite beams. Continuous beams. Special topics. Design projects.
 Mr. Zia.
- CE 544. Foundation Engineering** **3 or 3**
 Prerequisite: CE 442
 Subsoil investigations; excavations; design of sheeting and bracing systems; control of water; footing, grillage and pile foundations; caisson and cofferdam methods of construction; legal aspects of foundation engineering.
 Mr. Fadum.

CE 547. Fundamentals of Soil Mechanics**3 or 3**

Prerequisite: EM 321

Physical and mechanical properties of soils governing their use for engineering purposes; stress relations and applications to a variety of fundamental problems.

Mr. Fadum.

CE 548. Engineering Properties of Soils I**3-0**

Corequisite: CE 442

The study of soil properties that are significant in earthwork engineering, including properties of soil solids, basic clay mineral concepts, classification, identification, plasticity, permeability, capillarity and stabilization. Laboratory work includes classification, permeability and compaction tests.

Mr. Wahls.

CE 549. Engineering Problems of Soils II**0-3**

Prerequisite: CE 548

Continuation of CE 548, including the study of compressibility, stress-strain relations and shear strength theories for soil. Laboratory work includes consolidation and shear strength tests.

Mr. Wahls.

CE 570. Sanitary Microbiology**0-3**

(See BO 570)

CE 571. Theory of Water and Sewage Treatment**3-0**

Prerequisite: Senior standing

Study of the physical and chemical principles underlying water and sewage treatment processes; diffusion of gases, solubility, equilibrium and ionization, anaerobic and aerobic stabilization processes, sludge conditioning and disposal.

Mr. Smallwood.

CE 572. Unit Operations and Processes in Sanitary Engineering**0-3**

Prerequisite: CE 571

Processes and operations in sanitary engineering; sedimentation, aeration, filtration, adsorption, coagulation, softening, sludge digestion, aerobic treatment of sewage.

Mr. Smallwood.

CE 573. Analysis of Water and Sewage**3-0**

Corequisite: CE 571

Chemical and physical analysis of water and sewage and interpretation of results.

Mr. Smallwood.

CE 574. Radioactive Waste Disposal**3 or 3**

Prerequisite: PY 410

Unit operations and processes employed in treatment and disposal of radioactive wastes.

Mr. Smallwood.

CE 580. Flow in Open Channels**3 or 3**

Prerequisite: CE 481

The theory and applications of flow in open channels, including dimensional analysis, momentum-energy principle, gradually varied flow, high-velocity flow, energy dissipators, spillways, waves, channel transitions and model studies.

Mr. Amein.

CE 591., 592. Civil Engineering Seminar**1-1**

Discussions and reports of subjects in civil engineering and allied fields.

Graduate Staff.

CE 598. Civil Engineering Projects**Credits by arrangement**

Special projects in some phase of civil engineering.

Graduate Staff.

Courses for Graduates Only**CE 601. Transportation Planning****0-3**

Prerequisite: CE 515

The planning, administration, economics and financing of various transportation engineering facilities.

Messrs. Cribbins, Horn.

- CE 602. Advanced Transportation Design** **0-3**
 Prerequisite: CE 516
 Design of major traffic and transportation engineering projects.
 Messrs. Cribbins, Horn.
- CE 603. Airport Planning and Design** **3-0**
 Corequisite: CE 515 and 516
 The analysis, planning and design of air transportation facilities.
 Messrs. Cribbins, Horn.
- CE 604. Urban Transportation Planning** **0-3**
 Prerequisite: CE 515
 Thoroughfare planning as related to land usage and urban master-planning.
 Messrs. Cribbins, Horn.
- CE 623. Theory and Design of Arches** **3-0**
 Prerequisites: CE 428 and CE 526
 General theory of elastic arches. Boundary conditions and their effect on behavior of the arch. Single span, multiple span arches on elastic piers, influence lines of various functions under moving loads, economical layout of arches, design criteria for steel and concrete arches. Mr. Uyanik.
- CE 624. Analysis and Design of Structural Shells and Folded Plates** **0-3**
 Prerequisites: CE 623 and EM 511
 Roof structures consisting of surfaces of revolution, both single and compound curved. Membrane stresses, bending stresses at boundaries. Domes and cylindrical shells. Approximate and exact analyses. Design criteria. Folded plane structures of concrete plates and steel frames. Mr. Uyanik.
- CE 625, 626. Advanced Structural Design I, II** **3-3**
 Prerequisite: CE 428
 Corequisites: CE 525 and 526
 Complete structural designs of a variety of projects; principles of limit and prestress design. Mr. Uyanik.
- CE 627. Design of Blast Resistant Structures** **3-0**
 Prerequisites: CE 526, CE 535 and EM 554
 Sources, intensities, and methods of transmission of dynamic loads. Behavior of structural elements under dynamic loadings. Behavior of structural systems subjected to pulse and impact loads. Design criteria and factor of safety. Design of surface and underground structures for nuclear blasts. Mr. Bramer.
- CE 641, 642. Advanced Soil Mechanics** **3-3**
 Prerequisite: CE 442
 Corequisite: CE 547
 Theories of soil mechanics; failure conditions; mechanical interaction between solids and water, and problems in elasticity pertaining to earthwork engineering; soil dynamics. Mr. Fadum.
- CE 643. Hydraulics of Ground Water** **3 or 3**
 Prerequisite: CE 442 or CE 547
 Principles of ground water hydraulics; theory of flow through idealized porous media; the flow net solution; seepage and well problems. Mr. Fadum.
- CE 671. Advanced Water Supply and Sewerage** **4-0**
 Prerequisite: CE 482
 Problems relating to the design of water supply and sewerage works. Mr. Smallwood.
- CE 672. Advanced Water and Sewage Treatment** **0-4**
 Prerequisite: CE 482
 Problems relating to the treatment of water and sewage. Mr. Smallwood.

CE 673. Industrial Water Supply and Waste Disposal**3 or 3**

Corequisite: CE 571

Water requirements of industry and the disposal of industrial wastes.

Mr. Smallwood.

CE 674. Stream Sanitation**3 or 3**

Corequisite: CE 571

Biological, chemical and hydrological factors that affect stream sanitation and stream use.

Mr. Smallwood.

CE 698. Civil Engineering Research**Credits by arrangement**

Independent investigation of an advanced civil engineering problem; a report of such an investigation is required as a graduate thesis.

Graduate Staff.

DEPARTMENT OF CROP SCIENCE**Graduate Faculty**

Professors: PAUL HENRY HARVEY, *Head*, DOUGLAS SCALES CHAMBLEE, DAN ULRICH GERSTEL, WALTON CARLYLE GREGORY, GUY LANGSTON JONES, KENNETH R. KELLER, GLENN CHARLES KLINGMAN, ROY LEE LOVVORN, THURSTON JEFFERSON MANN, PHILIP ARTHUR MILLER, ROBERT PARKER MOORE, JOSEPH ARTHUR WEYBREW

Professor Emeritus: GORDON KENNEDY MIDDLETON

Associate Professors: CHARLES A. BRIM, HARRY DOUGLASS GROSS, LOUIS ALLMAN JONES, DONALD EDWIN MORELAND, LYLE L. PHILLIPS, LUTHER SHAW, DONALD LORAIN THOMPSON, DAVID H. TIMOTHY, ROBERT PHILLIP UPCHURCH

Assistant Professors: WILL ALLEN COPE, JOHN WESLEY DUDLEY, DONALD ALLEN EMERY, JOSHUA ALEXANDER LEE, JACK R. MAUNEY, EDWARD CARROLL SISLER

The Department of Crop Science offers to students interested in crop science training leading to the Master of Science and Doctor of Philosophy degrees in the fields of plant breeding, crop production, forage crops ecology, weed control, and plant chemistry. For students who wish a general training, the Master of Agriculture degree is offered.

Excellent facilities for graduate training are available. Each student is assigned office and laboratory space. In addition, many special facilities are available such as preparation rooms for plant and soil samples, cold storage facilities for plant material, air-conditioned rooms for studying the physical properties of cotton fiber and tobacco leaf, and soil and plant analytical service laboratories. Greenhouse space and growth control chambers are provided for projects which require special facilities. Sixteen farms are owned and operated by the State for research investigations. These farms are located throughout the State and include a wide variety of soil and climatic conditions needed for experiments in plant breeding, crop management, forage ecology, and weed control.

Strong supporting departments greatly increase the graduate students' opportunities for a broad and thorough training. Included among those departments in which graduate students in crop science work cooperatively or obtain instructions are botany, chemistry, genetics, horticultural science, mathematics, plant pathology, entomology, soil science, and statistics.

In North Carolina, a state which derives 80 per cent of its agricultural income from farm crops, the opportunities for the well trained agronomist are exceedingly great. The recipients of advanced degrees in crop science at North Carolina State College are found in positions of leadership in research and education throughout the nation and the world.

Courses for Advanced Undergraduates

CS 412. Advanced Pastures and Forage Crops 0-2
Prerequisite: CS 312

Pasture species and management (cultural treatment) from an international viewpoint, and the inter-relationship of grazing animals on pasture development and management will be emphasized. Natural grassland areas and the place of special plant species will be considered. Mr. Gross.

CS 413. Plant Breeding 0-3
Prerequisite: GN 411

The application of genetic principles to the improvement of economic plants, including discussions of the methods employed in the development and the perpetuation of desirable clones, varieties, and hybrids. Mr. Harvey.

CS 414. Weeds and Their Control. 3-0
Prerequisite: CH 203 or equivalent

Principles involved in cultural and chemical weed control. Discussions on chemistry of herbicides and the effects of the chemicals on the plant. Identification of common weeds and their seeds is given. Mr. Klingman.

Courses for Graduates and Advanced Undergraduates

CS 511. Tobacco Technology 0-2
Prerequisite: CS 311, BO 421 or equivalent

A study of special problems concerned with the tobacco crop. The latest research problems and findings dealing with this important cash crop will be discussed. Mr. Jones.

CS 521. Special Problems Credits by arrangement
Prerequisite: Admitted only with consent of instructor

Special problems in various phases of Field Crops. Problems may be selected or will be assigned. Emphasis will be placed on review of recent and current research. Graduate Staff.

CS 541. (GN 541 or HS 541) Plant Breeding Methods 3-0
Prerequisites: GN 512; recommended ST 511

An advanced study of methods of plant breeding as related to principles and concepts of inheritance. Messrs. Haynes, Timothy.

CS 542. (GN 542 or HS 542) Plant Breeding Field Procedures 2 in Summer Sessions

Prerequisites: CS 541 or GN 541 or HS 541
Laboratory and field study of the application of the various plant breeding techniques and methods used in the improvement of economic plants. Mr. Harvey.

Courses for Graduates Only*

CS 611. Forage Crop Ecology 0-2
Prerequisites: CS 412; BO 441

A study of the effect of environmental factors on the growth of forage crops. Attention will be given to methods of research in forage ecology. Mr. Chamblee.

* Students are expected to consult the instructor before registration.

CS 612. Special Topics in Weed Control**0-2**

Prerequisites or Corequisites: CS 414, BO 403, BO 532 or 533

Detailed examination of current concepts and literature of weed control. The chemistry, physiology, ecology, taxonomy, microbiology, equipment, and techniques used in weed control research will be discussed.

Graduate Staff.

CS 631. Seminar**1-1**

Prerequisites: Graduate Standing

Scientific articles, progress reports in research, and special problems of interest to agronomists reviewed and discussed.

A maximum of two credits is allowed towards the Master's degree, but any number towards the Doctorate.

Graduate Staff.

CS 641. Research**Credits by arrangement**

Prerequisites: Graduate standing

A maximum of two credits is allowed towards the master's degree, but any number towards the doctorate.

Graduate Staff.

DEPARTMENT OF ECONOMICS**Graduate Faculty***Professor: ERNST W. SWANSON, Head**Associate Professors: LOUIS A. DOW, CLEON HARRELL, BERNARD M. OLSEN**Assistant Professors: GERALD GARB, THOMAS H. PARK, CHING S. SHEN*

No graduate degrees are offered in economics at State College. The courses listed below are eligible for graduate credit when they form a part of an approved graduate program in other departments. Economics may serve as a minor field.

Courses for Advanced Undergraduates**EC 401, 402. Principles of Accounting****3-3**

Fundamental principles of accounting theory and practice; the analysis and recording of business transactions; explanation and interpretation of the structure, form, and use of financial statements.

EC 407. Business Law I**3 or 3**

Prerequisite: EC 201 or EC 205

A course dealing with elementary legal concepts, contracts, agency, negotiable instruments, sales of personal property, chattel mortgages, partnerships, corporations, suretyship and bailments, insurance.

EC 408. Business Law II**3 or 3**

Prerequisite: EC 407

Deals with real property, mortgages on urban and farm lands, landlord and tenant, requirements for valid deed, insurance law, wills, suretyship and conditional sales.

EC 409. Accounting for Production Costs**3-3**

Prerequisite: EC 312

An introduction to accounting problems peculiar to manufacturing, fabrication, and construction-type enterprises. Cost determination and allocation of costs for materials, labor, and overhead to the various units of product. Estimating and cost control in the production and manufacturing process. Special emphasis to be placed on managerial analysis and interpretation of cost data.

EC 410. Industry Studies**3-0**

Prerequisite: EC 201 or EC 205

An analysis of organization, market structure, and competitive behavior in specific industries, using the tools of the economist as a guide to pertinent factors and their significance. The course will be organized along the lines of intensive but broadly-relevant case-studies.

EC 411. Marketing Methods**3-3**

Prerequisite: EC 201 or EC 205

Marketing institutions and their functions and agencies; retailing; market analysis; problems in marketing.

EC 413. Competition, Monopoly, and Public Policy**3-3**

Prerequisite: EC 201 or EC 205, EC 301 recommended but not required

An analysis of the effect of modern industrial structure on competitive behavior and performance, in the light of contemporary price theory and the theory of workable competition. A critical evaluation of the legislative content, judicial interpretation, and economic effects of the antitrust laws.

EC 414. Tax Accounting**3 or 3**

Prerequisite: EC 312 or EC 401

An analysis of the Federal tax laws relating to the individual and business. Determining and reporting income. Payroll taxes and methods of reporting them. Actual practice in the preparation of income tax returns.

EC 420. Corporation Finance**3 or 3**

Prerequisite: EC 201 or EC 205

Financial instruments and capital structure; procuring funds; managing working capital; managing corporate capitalization; financial institutions and their work.

EC 425. Industrial Management**3-0**

Prerequisite: Junior standing

Principles and techniques of modern scientific management; relation of finance, marketing, industrial relations, accounting, and statistics to production; production planning and control; analysis of economic, political and social influences on production.

EC 426. Personnel Management**0-3**

Prerequisite: Junior standing

The scientific management of manpower, from the viewpoint of the supervisor and the personnel specialist. A study of personnel policy and a review of the scientific techniques regarding the specific problems of employment, training, promotion, transfer, health and safety, employee services, and joint relations.

EC 431. Labor Problems**3 or 3**

Prerequisite: Junior standing

An economic approach to labor problems including wages, hours, working conditions, insecurity, substandard workers, minority groups, social security, and public policy relative to these problems.

EC 432. Industrial Relations**3 or 3**

Prerequisite: Junior standing

Collective bargaining. Analysis of basic labor law and its interpretation by the courts and governmental agencies. An examination of specific terms of labor contracts and their implications for labor and management. An examination of labor objectives and tactics and management objectives and tactics. Problems of operating under the labor contract.

EC 440. Economics of Growth**0-3**

Prerequisite: EC 201 or EC 205

An examination of the institutional background required for national economic development. The conditions apparent for past growth of nations are

compared with conditions obtaining in presently retarded nations. Conclusions are drawn from this comparison to provide an introduction to theoretical models of growth.

EC 442. Evolution of Economic Ideas

0-3

Prerequisite: EC 201 or EC 205

An analysis of the development of economic thought and method during the past two centuries. Economics considered as a cumulative body of knowledge, in a context of emerging technology, changing institutions, pressing new problems, and the growth of science.

EC 446. Economic Forecasting

3-0

Prerequisite: EC 201 or EC 205. EC 302 recommended but not required

An examination of the basic principles and techniques of economic forecasting with strong emphasis upon the economic models upon which forecasting is based.

EC 448. International Economics

3-0

Prerequisite: EC 201 or EC 205

A study of international economics, including trade, investment, monetary relations, and certain aspects of economic development. Emphasis upon analytical and policy approaches, although some institutional material is included.

EC 450. Economic Decision Processes

0-3

Prerequisites: EC 201 or EC 205 and Math 202 or Math 212

An analysis of processes for decision making by individuals and groups. Linear programming, probability, and game theory in the light of a general theory of decision.

EC 490. Senior Seminar in Economics

3 or 3

Prerequisite: Consent of Instructor

The terminal course in undergraduate study of economics. The student is assisted in summarizing his training, and in improving his capacity to recognize problems and to select logically consistent means of solving the problems. This is done on a small-group and individual basis.

Courses for Graduates and Advanced Undergraduates

EC 501. (AGC 501) Intermediate Economic Theory

3-0

Prerequisite: EC 301 or AGC 212, or equivalent

An intensive analysis of the determination of prices and of market behavior, including demand, cost and production, pricing under competitive conditions, and pricing under monopoly and other imperfectly competitive conditions. Messrs. Dow, Garb, Park, Shen.

EC 502. Money, Income, and Employment

0-3

Prerequisite: EC 302 or EC 501, or equivalent

A study of the methods and concepts of national income analysis with particular reference to the role of monetary policy in maintaining full employment without inflation. Messrs. Garb, Olsen, Shen.

EC 510. (PS 510) Public Finance

3 or 3

Prerequisite: EC 201 or EC 205

A survey of the theories and practices of governmental taxing, spending, and borrowing, including intergovernmental relationships and administrative practices and problems. Mr. Block.

EC 525. Management Policy and Decision Making

3-0

Prerequisites: 9 hours in Economics and related courses and consent of the instructor.

A review and consideration of modern management processes used in making top-level policies and decisions. An evaluation of economic, social and in-

stitutional pressures, and of the economic and non-economic motivations, which impinge upon the individual and the organization. The problem of coordinating the objectives and the mechanics of management is examined.
Messrs. Bartley, Wood.

EC 531. Management of Industrial Relations

0-3

Prerequisites: 9 hours in Economics and related courses and consent of the instructor

A seminar course designed to round out the technical student's program. Includes a survey of the labor movement organization and structure of unions, labor law and public policy, the union contract, the bargaining process, and current trends and tendencies in the field of collective bargaining.
Messrs. Bartley, Wood.

EC 541. Origins of the United States' Economy.

3-0

Prerequisites: Senior or Graduate standing; EC 205, HI 261, or HI 333, or equivalent.

A seminar on growth and development of American economic institutions. Emphasis is placed on the relationship between the growth of the economy of the United States and theories of economic development. Mr. Olsen.

EC 550. Mathematical Models in Economics

3 or 3

Prerequisites: EC 201 or EC 205 and MA 202 or MA 212. EC 450 recommended but not required.

An introductory study of economic models emphasizing their formal properties. The theory of individual economic units is presented as a special case in the theory of inductive behavior. Mathematical discussions of the theory of the consumer, the theory of the firm, and welfare economics will show the relevance of such topics as constrained maxima and minima, set theory, partially and simply ordered systems, probability theory, and game theory to economics.
Mr. Harrell.

EC 552. Econometrics

0-3

Prerequisites: EC 201 or EC 205 and MA 202 or MA 212 and MA 405; ST 362

Recent developments in the theory of production, allocation, and organization. Optimal combination of integrated productive processes within the firm. Applications in the economics of industry and of agriculture.
Mr. Harrell.

EC 555. Linear Programming.

3-3

Prerequisites: EC 201 or EC 205, MA 202 or MA 212, MA 405

Recent developments in the theory of production, allocation, and organization. Optimal combination of integrated productive processes within the firm. Applications in the economics of industry and of agriculture.
Mr. Harrell.

EC 590, 591. Seminar in Special Economic Topics

3 or 3

Prerequisite: Consent of instructor

Topics presented by a visiting professor or special lecturer. This course will be offered from time to time as distinguished visiting scholars are available.

Courses for Graduates Only

EC 601. Advanced Economic Theory

3 or 3

Prerequisite: EC 501, or equivalent

A rigorous examination of contemporary microeconomic theory.

Messrs. Dow, Garb, Shen, Swanson.

EC 602. (AGC 602) Monetary and Employment Theory

3 or 3

Prerequisite: EC 502, or equivalent

The course consists of an analysis of the forces determining the level of

income and employment; a review of some of the theories of economic fluctuations; and a critical examination of a selected macroeconomic system.

Messrs. Garb, Olson, Shen.

EC 603. History of Economic Thought

3 or 3

Prerequisite: EC 442 or EC 501, or equivalent

A systematic analysis of the development and cumulation of economic thought, designed in part to provide a sharper focus and more adequate perspective for the understanding of contemporary economics.

Messrs. Olsen, Garb, Swanson.

EC 605. Research in Economics

Credits by arrangement

Prerequisite: Graduate standing

Individual research in economics, under staff supervision and direction.

Staff.

EC 640. Theory of Economic Growth

3 or 3

Prerequisite: EC 440 or EC 502, or equivalent

Several theoretical models of economic growth are compared and analyzed. Contemporary developments in the theory of national economic growth are studied and evaluated for consistency with older theories.

Mr. Olsen.

EC 648. Theory of International Trade

0-3

Prerequisite: EC 448 or EC 501, or equivalent

A consideration, on a seminar basis, of the specialized body of economic theory dealing with the international movement of goods, services, capital, and payments. Also, a theoretically-oriented consideration of policy.

Mr. Swanson.

EC 650. Economic Decision Theory

3-0

Prerequisites: EC 501 or equivalent; EC 550 or EC 555

Study of general theories of choice. Structure of decision problems; the role of information; formulation of objectives. Current research problems.

Mr. Harrell.

EC 655. Topics in Mathematical Economics

3 or 3

Prerequisites: EC 501 or equivalent; EC 550 or EC 555

A seminar and research course devoted to recent literature and developments in mathematical economics.

Messrs. Garb, Harrell.

EC 665. Economic Behavior of the Organization

0-3

Prerequisites: EC 501 or equivalent, and consent of instructor

This seminar will apply methods and findings derived from the behavioral sciences to the economic behavior of the organization, particularly the business firm. Among the approaches which may be utilized are organization theory, information theory, reference group theory, and decision theory.

Messrs. Harrell, Swanson.

SCHOOL OF EDUCATION*

JAMES BRYANT KIRKLAND, *Dean*

Associate Professor: HERBERT ELVIN SPEECE

The School of Education offers graduate programs leading to the master's degree in agricultural education, industrial arts education, industrial education, occupational information and guidance, and industrial psychology. Graduate students in education may pursue programs leading to the Master of Science degree or to the master's degree in a professional field. Both degrees are recognized by the State Department of Education.

* Following the School of Education's general write-up and description of courses are sections pertaining to the departments within the school.

The Master of Science degree is regarded as a research degree and as preparation for further graduate study. Programs leading to the Master of Science degree are planned to include a major (twenty credit hours) in some specialized area of education and a minor (ten or more credit hours) in some other field such as psychology or agricultural economics. If two minors are chosen, a minimum of six credits will be required in each.

A reading knowledge of one modern foreign language is required.

A thesis representing an original investigation in the major field must be prepared.

The master's degree in a professional field is designed to meet the needs of students who are preparing themselves for teaching in the secondary schools. The program of study meeting the requirements for the professional degree differs from that for the Master of Science degree in that in the former a wider latitude is permitted in the choice of course work outside the major.

A problem may be substituted for a thesis if, in the opinion of the student's advisory committee, this alternative contributes maximally to the student's objective.

A knowledge of a foreign language is not required to meet the requirements for the professional degree.

A total of at least thirty credit hours is required, at least eight hours of which must be in course work at the 600 level. Not more than six semester hours will be accepted at the 400 level and all of these must fall outside of the major field.

The School of Education is located in Tompkins Hall where well equipped laboratories and research facilities are provided for graduate study.

A limited number of teaching and research assistantships are available for qualified graduate students. N.D.E.A. loans are also available for graduate students needing financial aid.

General Courses

Courses for Graduates and Advanced Undergraduates

ED 501. Education of Exceptional Children **3-0**

Advanced undergraduates or graduates. Prerequisite: six hours in education or psychology

Discussion of principles and techniques of teaching the exceptional child with major interest on the mentally handicapped and slow learner. Practice will be given in curriculum instruction for groups of children, individual techniques for dealing with retarded children in the average classroom. Opportunity for individual work with an exceptional child will be provided.

Mr. Corter.

ED 502. Analysis of Reading Abilities

3 or 3

Prerequisites: Six hours in education or psychology

A study of tests and techniques in determining specific abilities; a study of reading retardation and factors underlying reading difficulties.

Mr. Rust.

ED 503. Improvement of Reading Abilities

3 or 3

Prerequisites: Six hours of education or psychology

A study of methods used in developing specific reading skills or in over-

coming certain reading difficulties; a study of methods used in developing pupil vocabularies and work analysis skills; a study of how to control vocabulary burden of reading material.

Mr. Rust.

ED 552. Industrial Arts in the Elementary School

3 or 3

Prerequisites: Twelve credits in education and consent of instructor

This course is organized to help elementary teachers and principals understand how tools and materials and industrial processes may be used to vitalize and supplement the elementary school children's experiences. Practical children's projects along with the building of classroom equipment.

Mr. Hostetler.

ED 563. Effective Teaching

3 or 3

Prerequisite: Twelve hours in Education

Analysis of the teaching-learning process; assumptions that underlie course approaches; identifying problems of importance; problem solution for effective learning; relationship of learning and doing; responsibility for learnings; evaluation of teaching and learning; making specific plans for effective teaching.

Mr. Scarborough.

***ED 595. (IA) Industrial Arts Workshop**

3

Prerequisites: One or more years of teaching experience

A course for experienced teachers, administrators and supervisors of industrial arts. The primary purpose will be to develop sound principles and practices for initiating, conducting and evaluating programs in this field. Enrollees will pool their knowledge and practical experiences and will do intensive research work on individual and group problems.

Mr. Hostetler.

Courses for Graduates Only

ED 614. Modern Principles and Practices in Secondary Education

2 or 2

Prerequisite: Twelve hours in Education

Foundations of modern programs of secondary education purposes, curriculum, organization, administration, and the place and importance of the high school in the community in relation to contemporary social force.

Graduate Staff.

ED 615. Introduction to Education Research

3-0

Prerequisite: Twelve hours in Education

An introductory course for students preparing for an advanced degree. The purposes are: to assist the student in understanding the meaning and purpose of educational research and the research approach to problems; to develop students' ability to identify educational problems, and to plan and carry out research to solve these problems; to aid in the preparation of the research report. Special attention is given to tools and methods of research. Consideration is also given to the educator as a consumer of research.

Graduate Staff.

ED 665. Supervising Student Teaching

3 or 3

Prerequisite: Twelve hours in Education

A study of the program of student teaching in teacher education. Special consideration will be given the role of the supervising teacher including the following areas: planning for effective student teaching, observation and orientation, school community study, analysis of situation, evaluating student teacher, and coordination with State College.

Graduate Staff.

* Offered in Summer School only.

DEPARTMENT OF AGRICULTURAL EDUCATION

Graduate Faculty

Professors: CLARENCE CAYCE SCARBOROUGH, *Head*, JAMES BRYANT KIRKLAND
Adjunct Professor: GERALD BLAINE JAMES

The Department of Agricultural Education offers programs of study leading to the Master of Science and the Master of Agricultural Education degrees.

The department has designed its graduate programs to meet the needs of the individual student in the area of agricultural education. Also, the department emphasizes instruction that will prepare the student for the role of a local educational leader. In addition to agricultural education courses, most programs include courses in rural sociology and agricultural economics. Courses in public administration are included in some of the programs.

All of the programs in the department emphasize research. As a part of the graduate program, each student must complete a thesis or a research problem.

In addition to the many resources available to all State College graduate students, agricultural education students are privileged to have available administrative and supervisory personnel staff members of the State Department of Public Instruction which is located in Raleigh. The State Director of Vocational Education, a former member of the State College graduate faculty, is available as consultant and adviser to graduate students in the agricultural education field. Other members of the State Department of Public Instruction staff are also available for consultation.

A limited number of assistantships are available. Preference is given to experienced educational leaders in the field.

Courses for Graduates and Advanced Undergraduates

ED 554. Planning Programs in Agricultural Education

3 or 3

Prerequisite: ED 411 or equivalent

Consideration of the community as a unit for planning programs in Agricultural Education; objectives and evaluation of community programs; use of advisory groups; school and community relationships; organization and use of facilities; role of the leader.

Messrs. Scarborough, Beam.

ED 558. Special Problems in Teaching

Maximum 6 credits

Prerequisite: ED 411 or equivalent

Current problems in teaching. Opportunities for students to study particular problems under the guidance of the staff.

Graduate Staff.

ED 563. Effective Teaching

(See Education)

ED 568. Adult Education in Agriculture

3 or 3

Prerequisite: ED 411 or equivalent

This course is designed to meet the needs of leaders in adult education. This course will give the leader an opportunity to study some of the basic problems and values in working with adult groups. Particular attention will be given to the leadership role problem in educational programs for adults.

Messrs. Scarborough, Beam.

Courses for Graduates Only

ED 615. Introduction to Educational Research.

(See Education)

ED 616. Advanced Problems in Teaching

3 or 3

Prerequisite: ED 558

Study of current and advanced problems in the teaching and administration of educational programs; evaluation of procedures and consideration for improving.

Graduate Staff.

ED 617. Philosophy of Agricultural Education

3 or 3

Prerequisite: ED 554 or equivalent

An examination of current educational philosophies and their relation to agricultural education. Principles and practices involved in the leadership of a teacher of agriculture and in making his work effective in a rural community. Study of leaders in the field.

Mr. Scarborough.

ED 618. Seminar in Agricultural Education

Maximum 2 credits

A critical review of current problems, articles, and books of interest to students of agricultural education.

Graduate Staff.

ED 621. Research in Agricultural Education

Maximum 6 credits

Individual direction in research on a specific problem of concern to the student. Generally, the student is preparing his thesis or research problem.

Graduate Staff.

ED 664. Supervision in Agricultural Education

3 or 3

Prerequisite: ED 563 or equivalent

Organization, administration, evaluation and possible improvement of present supervisory practice; theory, principles and techniques of effective supervision in agricultural education at different levels.

Messrs. Kirkland, Scarborough.

ED 665. Supervising Student Teaching

(See Education)

DEPARTMENT OF INDUSTRIAL ARTS

Graduate Faculty

Professor: IVAN HOSTETLER, Head

Associate Professor: TALMAGE B. YOUNG

The Department of Industrial Arts offers graduate work leading to the Master of Science degree and the Master of Industrial Arts degree. Industrial Arts majors may select one or two minors in such fields as guidance, psychology, sociology, or school administration.

Professional and laboratory courses are provided on the graduate level to assure a well-rounded program of graduate studies. Special emphasis is being given and special funds provided for the development of an Experimental Laboratory with specialized equipment which will be used exclusively by advanced undergraduate and graduate students for experimentation and research. The industrial arts facilities of the public schools are also available for research work.

Teaching and graduate assistantships are available each year for experienced teachers interested in pursuing graduate work. Loans may also be secured through the N.D.E.A. for graduate students.

Holders of master's degrees in industrial arts education are much in demand for supervisory and teaching positions in the public schools and colleges.

Courses for Graduates and Advanced Undergraduates

IA 510. Design for Industrial Arts Teachers **3 or 3**

Prerequisites: 6 hours of Drawing and IA 205 or equivalent

A study of new developments in the field of design with emphasis on the relationship of material and form in the selection and designing of industrial arts projects. Graduate Staff.

ED 552. Industrial Arts in the Elementary School

IA 560. (ED 560) New Developments in Industrial Arts Education **3 or 3**

Prerequisites: 12 hours in education and teaching experience

This course is a study of the new developments in industrial arts education. It is designed to assist teachers and administrators in developing new concepts and new content based on the changes in technology. They will be required to re-evaluate their programs in the light of these new concepts and the new content. Mr. Hostetler.

IA 570. Laboratory Problems in Industrial Arts **Maximum 6**

Prerequisites: Senior standing and permission of instructor

Courses based on individual problems and designed to give advanced majors in industrial arts education the opportunity to broaden or intensify their knowledge and abilities through investigation and research in the various fields of industrial arts, such as metals, plastics, or ceramics. Graduate Staff.

IA 575. Special Problems in Industrial Arts

Maximum 6

Prerequisite: One term of student teaching or equivalent

The purpose of these courses is to broaden the subject matter experiences in the areas of industrial arts. Problems involving experimentation, investigation and research in one or more industrial arts areas will be required. Graduate Staff.

IA 595. (ED 595) Industrial Arts Workshop

3 credits

Prerequisite: One or more years of teaching experience

A course for experienced teachers, administrators and supervisors of industrial arts. The primary purpose will be to develop sound principles and practices for initiating, conducting and evaluating programs in this field. Enrollees will pool their knowledge and practical experiences and will do intensive research work on individual and group problems. Mr. Hostetler.

(Offered at Summer School only.)

Courses for Graduates Only

ED 619. Seminar in Industrial Arts Education

Maximum 6

Prerequisite: Graduate standing

Reviews and reports on special topics of interest to students in industrial arts education. Mr. Hostetler.

ED 624. Research in Industrial Arts Education

Maximum 6

Prerequisites: Eighteen credits in Education and permission of instructor

The student will be guided in the selection of one or more research problems and in the organization of the problems, methods of gathering data, procedure for analyzing data, and best practice for interpreting and reporting data. Mr. Hostetler.

ED 630. Philosophy of Industrial Arts

2 or 2

Prerequisite: Twelve hours in Education

Required of all graduate students in Industrial Arts Education

Current and historical developments in industrial arts; philosophical concepts, functions, scope, criteria for the selection and evaluation of learning experiences, laboratory organization, student personnel program, community relationships, teacher qualifications, and problems confronting the industrial arts profession.

Mr. Hostetler.

ED 635. Administration and Supervision of Industrial Arts

2 or 2

Prerequisite: Twelve hours in Education

A study of the problems and techniques of administration and supervision in the improvement of industrial arts in the public schools. Selection of teachers and their improvement in service and methods of evaluating industrial arts programs.

Mr. Hostetler.

DEPARTMENT OF INDUSTRIAL EDUCATION

Graduate Faculty

Professor: DURWIN M. HANSON, Head

The Department of Industrial Education offers graduate work leading to the degrees of Master of Science and Master of Industrial Education. The rapid development of industrial and technical education in North Carolina and throughout the nation provides many opportunities for teachers and administrators who have earned advanced degrees.

The facilities at State College afford an excellent program of supporting courses at the graduate level in the related fields of science, mathematics, guidance, psychology, sociology, economics, statistics, and engineering. The prerequisite for graduate work in industrial education is a proficiency in the undergraduate courses required for the bachelor's degree in industrial education, or a substantial equivalent.

A limited number of teaching and research assistantships are available for qualified graduate students.

Courses for Graduates and Advanced Undergraduates

ED 516. Community Occupational Surveys

0-2

Prerequisites: Six credits in Education and consent of instructor

Methods in organizing and conducting local surveys and evaluation of findings in planning a program of vocational education.

Graduate Staff.

ED 521. Organization of Related Study Materials

3 or 3

Prerequisite: ED 422

The principles of selecting and organizing both technical and general related instructional material for trade extension and industrial cooperative training classes.

Graduate Staff.

ED 525. Trade Analysis and Course Construction

3-0

Prerequisites: ED 344, PSY 304

Principles and practices in analyzing occupations for the purpose of determining teaching content. Practice in the principles underlying industrial course organization based on occupational analysis covering instruction in skills and technology and including course outlines, job sequences, the development of instructional materials and schedules.

Graduate Staff.

ED 527. Philosophy of Industrial and Technical Education

0-3

Prerequisites: ED 422, 440

A presentation of the historical development of industrial and technical

education; the types of programs, philosophy, trends and problems of vocational-industrial education; study of Federal and State legislation pertaining to industrial education, practical nurse education and technical education.

Mr. Hanson.

ED 528. Principles and Practices in Industrial Cooperative Training **3 or 3**
Prerequisites: ED 422, 440

A study of the developments, the objectives, and principles of industrial cooperative training. The organization, promotion and management of programs in this area of vocational education.

Graduate Staff.

ED 529. Curriculum Materials Development **3 or 3**
Prerequisite: ED 525

Selection and organization of curricula used in vocational-industrial and technical education; development of curricula and instructional materials.

Mr. Hanson.

ED 591. Special Problems in Industrial Education **Maximum 6**

Prerequisites: 6 hours graduate work and permission of department head
Directed study other than thesis problem to provide individualized study and analysis in a specialized area of trade, industrial or technical education.

Mr. Hanson.

Courses for Graduates Only

ED 609. Planning and Organizing Technical Education Programs **3 or 3**
Prerequisites: PSY 304, ED 344, 420, 440, and 516

Principles of planning and organizing technical education programs sponsored by federal vocational acts. Professional course for coordinators and directors, with emphasis on the organization of post high school technical education level. Survey of needs, building plans, equipping and maintenance of buildings, financial structure, and personnel organization and management.

Mr. Hanson.

ED 610. Administration and Supervision of Vocational Education **3 or 3**
Prerequisites: PSY 304, ED 334, 420, 440 or equivalent

Administrative and supervisory problems of vocational education; practices and policies of Federal and State offices; organization and administration of city and consolidated systems.

Mr. Hanson.

ED 626. Seminar in Industrial Education **Maximum 2**
Prerequisite: Graduate standing or permission of the instructor

Reviews and reports on topics of special interest to graduate students in Industrial Education. The course will be offered from time to time in accordance with the availability of distinguished professors.

Mr. Hanson.

ED 627. Research in Industrial Education **Maximum 6**
Prerequisites: Eighteen credits in Education and permission of instructor

The student will be guided in the selection of one or more research problems and in the organization of the problems, methods of gathering data, procedure for analyzing data, and best practice for interpreting and reporting data.

Graduate Staff.

DEPARTMENT OF OCCUPATIONAL INFORMATION AND GUIDANCE

Graduate Faculty

Professor: ROY N. ANDERSON, *Head*

Associate Professor: CHARLES G. MOREHEAD

The Department of Occupational Information and Guidance has been training guidance and personnel workers for more than four decades. The

first master's degree was awarded in 1926. The programs of graduate study are planned to develop a broad understanding of guidance and personnel services to be applied in various settings. It is most desirable for an applicant who wishes to specialize in guidance and personnel services to have had undergraduate course work in economics, education, psychology, sociology, or social work. Students accepted into the program are those who anticipate devoting full or part time to guidance and personnel work. Teachers, administrators and others who wish to increase their knowledge of guidance and personnel may enroll for courses as a graduate minor or for certification renewal.

Professional opportunities for placement in this field are on the increase. The department prepares students for positions as counselors in secondary schools, industrial education centers, colleges, community agencies; school or county guidance directors, rehabilitation counselors, employment counselors, placement interviewers, and personnel workers in higher education, business or industry, and State and Federal Government agencies. The student may specialize in one of several areas depending upon his vocational goals.

The master's program includes a core of guidance and personnel courses to be selected according to the student's vocational goals. Students may select their minor from the following areas: economics, psychology, sociology and anthropology. The master's degree program of the department meets the requirements for the Counselor's Certificate issued by the North Carolina State Department of Public Instruction, as well as counselor certification in many other states.

The Department of Occupational Information and Guidance has had a contract with the Office of Vocational Rehabilitation for the training of Rehabilitation Counselors, and has been awarded four Counseling and Guidance Training Institutes under contract with the United States Office of Education as authorized by the National Defense Education Act of 1958.

The department also provides service courses in guidance and personnel for undergraduate students in the School of Education.

Courses for Graduates and Advanced Undergraduates

ED 524. Occupational Information

0-3

Prerequisites: 6 hours of education or psychology and ED 420 or equivalent. This course is designed to prepare teachers, counselors, business and industrial personnel workers, placement workers, and others to collect, evaluate, and use occupational and educational information. In addition to the study of the usual sources and types of published occupational information, attention will be given to collection of occupational information locally, preparation of the occupational monograph, analysis of job requirements and worker characteristics, occupational trends and factors affecting trends, occupational information to groups and individuals by techniques such as the following are considered: The occupations unit in social studies and other courses, the occupations course, home-room activities, introducing occupational information informally in subject matter courses, the resource file, vocational counseling.

Mr. Morehead.

ED 530. Group Guidance

0-3

Prerequisites: 6 hours of education or psychology and ED 420 or equivalent. This course is designed to help teachers, counselors, administrators, and

others who work with groups or who are responsible for group guidance activities, to understand the theory and principles of effective group work, to develop skill in using specific guidance techniques, and to plan and organize group activities in the secondary school and other institutions. The relationship of group activities to counseling and other aspects of guidance services is considered. Methods of evaluating and improving group guidance activities are taken up.

Mr. Morehead.

ED 533. Organization and Administration of Guidance Services 3-0

Prerequisites: Graduate standing and ED 420 or equivalent

This course is designed for school guidance workers and those preparing for this field. Basic principles and current practices employed in developing, organizing, administering, and supervising guidance services in the elementary and secondary school will be studied. Interrelationships of guidance services with instruction, administrative relationships, utilization of school staff, and evaluation of guidance services will be considered.

Mr. Morehead.

ED 590. Individual Problems in Guidance Maximum 6 credits

Prerequisites: 6 hours graduate work in Department or equivalent

Intended for individual or group studies of one or more of the major problems in guidance and personnel work. Problems will be selected to meet the interests of individuals. The workshop procedure will be used whereby special projects and reports will be developed by individuals and by groups.

Messrs. Anderson, Morehead.

Courses for Graduates Only

ED 631. Educational and Vocational Guidance 3-0

Prerequisites: 9 hours from following fields—Economics, Education, Psychology or Sociology

This course aims to provide training for teachers who are part-time or full-time counselors, employment interviews, social workers and personnel workers, who are aiding individuals with vocational adjustment problems. The course will cover the functions performed in vocational and educational guidance such as assembling and imparting occupational information, counseling regarding vocational and educational plans, the use of aptitude tests, placement in jobs and follow-up, and procedures in setting up services of vocational and educational guidance in schools, employment offices, and social service agencies.

Mr. Anderson.

ED 633. Techniques in Guidance and Personnel 0-3

Prerequisites: 9 hours from following fields—Economics, Education, Psychology or Sociology

This course is designed to aid personnel workers in secondary schools, colleges, employment offices, and social agencies to develop an understanding and to develop skill in using various guidance and personnel techniques. Some of the techniques to be studied intensively are: anecdotal reports, rating scales, observation, records and reports, sociograms, interviewing, counseling and case study procedures. Students will become acquainted with these techniques through lectures, demonstrations, and the study of case histories. Attention will be given to both diagnosis and treatment.

Mr. Anderson.

ED 641. Field Work in Occupational Information and Guidance 2 to 6, 2 to 6

Prerequisite: Advanced graduate standing

A practicum course in which the student undertakes field work in secondary schools, colleges, social service agencies, employment office, and industrial establishments which carry on guidance and personnel work. The student

may observe and participate in some personnel service and may study the organization and administration of the programs.

Messrs. Anderson, Morehead.

ED 651. Research in Occupational Information and Guidance **Maximum 6 credits f s**

Prerequisite: Advanced graduate standing

Qualified students will conduct investigations and research in guidance and personnel. Published reports and techniques in investigation will be analyzed and evaluated.

Messrs. Anderson, Morehead.

DEPARTMENT OF PSYCHOLOGY

Graduate Faculty

Professors: HOWARD G. MILLER, *Head*, KEY L. BARKLEY, HAROLD M. CORTER

Associate Professors: JOHN OLIVER COOK, JOSEPH CLYDE JOHNSON, SLATER E.

NEWMAN, PAUL J. RUST

Assistant Professors: DONALD W. DREWES, CLIFTON W. GRAY

The Department of Psychology offers courses leading to the Master of Science degree. An industrial option includes courses in the application of scientific methods to the study of industrial behavior based on strong research training. An experimental option provides a program with major emphasis on the development of proficiency in experimental methodology in psychological research. Courses are also offered which provide professional competence in school psychology.

All programs are designed to provide the student with solid grounding in the basic areas of psychology. A set of required core courses includes statistics, social psychology, experimental psychology, psychology of personality, and the theory and method of measurement.

A minimum of thirty semester hours of graduate credit is required for the master's degree, but the actual graduate program for each student is determined on the basis of his individual needs, interests, and accomplishments and very likely will require hours in excess of this minimum.

Admission requirements for graduate study in the Department of Psychology are a minimum of twenty semester credit hours in undergraduate psychology, the maintenance of a "B" average in undergraduate psychology courses, satisfactory grades in other collegiate studies, and satisfactory references from faculty and others in regard to character and quality of work. In some special cases provisional acceptance is granted where some of the requirements are not met.

The physical facilities for the training of graduate students in psychology include testing, statistics, general and human engineering laboratories.

In addition to teaching and basic research activities, the Department of Psychology carries on research for industrial, military and other organizations. To facilitate this activity, the Industrial Psychology Center has been established as a special organization within the department.

A limited number of research and teaching assistantships are available annually. These assistantships are usually based on one-third time assignments, but are also occasionally for one-half time.

Courses for Advanced Undergraduates

PSY 438. Industrial Psychology II
0-3

Prerequisites: PSY 200, PSY 337

The application of psychological principles to the problems of modern industry; with particular emphasis on human relations and supervision.

Mr. Miller.

PSY 441. Human Factors in Equipment Design
0-3

Prerequisites: PSY 200, PSY 337 recommended

Human factors in the design of machines and other equipment. Items of equipment are understood as extensions of man's capacity to sense, comprehend, and control his environment. Includes problems in the psychology of information, communication, control, and invention.

Messrs. Cook, Gray.

PSY 464. Visual Perception for Designers
3-0

Prerequisite: PSY 200

The nature of the seeing process and its relation to architecture, industrial arts, and to the industrial engineering, and textile design fields. Topics include the basis of sight, perception of color and form, vision and illumination, psychological factors in visual design, and a unit of training planned to improve the student's ability to perceive visual form.

Mr. Cook.

PSY 475. Child Psychology
0-3

Prerequisite: PSY 200 or PSY 304

The development of the individual child of the elementary school age will be the inclusive object of study in this course. Emphasis will be placed upon the intellectual, social, emotional, and personality development of the child. Physical growth will be emphasized as necessary to an understanding of the psychological development of the pupil.

Mr. Barkley.

PSY 476. Psychology of Adolescence
2-2

Prerequisite: PSY 200

Nature and source of the problems of adolescents in western culture; emotional, social, intellectual and personality development of adolescents.

Messrs. Barkley, Johnson.

PSY 490. Social Psychology
0-3

Prerequisite: PSY 200

The individual in relation to social factors. Socialization, personality development, communication, social conflict and social change.

Messrs. Barkley, Miller.

Courses for Graduates and Advanced Undergraduates

PSY 501. Experimental Psychology
3-3

Prerequisite: 9 hours of Psychology

Experimental study of problems in general and theoretical psychology with particular emphasis on sensation and perception. Particular attention is paid to problem formulation, experimental design and experimental method. Effective written and oral performance by the student is a basic objective.

Messrs. Barkley, Cook, Newman.

PSY 502. Physiological Psychology
3-0

Prerequisites: 12 hours of Psychology, including PSY 200, PSY 201

A survey of the physiological bases of behavior including the study of coordination, sensory processes, brain functions, emotions, and motivation.

Messrs. Corter, Bernard.

PSY 504. Advanced Educational Psychology**0-3**

Prerequisites: Six hours in Psychology

A critical appraisal of current psychological findings that are relevant to educational practice and theory.

Mr. Johnson.

PSY 511. Advanced Social Psychology**3-0**

Prerequisites: PSY 200 and 514 additional hours in Psychology

A study of social relationships and their psychological bases; emphasis on those aspects of behavior determined by personal interactions; work will involve analysis of representative research studies, and individual projects.

Mr. Miller.

PSY 514. Psychological Research Design**1-0**

Prerequisite: Graduate standing in Psychology

The objectives of this course are to acquaint students with current developments in theory and research in several areas of psychological interest; to foster capability to derive experimentally testable hypotheses, and experimental tests of these hypotheses; to write and speak effectively about theory and experimentation in psychology.

Graduate Staff.

PSY 530. Abnormal Psychology**0-3**

Prerequisites: PSY 200, PSY 302

A study of the causes, symptomatic behavior, and treatment of the major personality disturbances, emphasis also placed on preventive mental hygiene methods.

Mr. Corter.

PSY 535. Tests and Measurements**3-3**

Prerequisite: Six hours in Psychology

A study of standard tests with an emphasis on the different selection and use of such instruments.

Mr. Johnson.

PSY 550. Mental Hygiene in Teaching**3-0**

Prerequisite: Six hours in Psychology

A survey of mental hygiene principles applicable to teachers and pupils; practical problems in prevention and treatment of psychological problems in schools; case studies and research.

Messrs. Barkley, Corter.

PSY 565. Industrial Management Psychology**3-3**

Prerequisites: 9 hours of Psychology

A study of the application of behavioral science, particularly psychology and social psychology to organizational and management problems.

Mr. Miller.

PSY 570. Theories of Personality**3-0**

Prerequisite: 9 hours in Psychology

A survey of modern theories of personality with some emphasis on intelligence and cognitive factors.

Mr. Corter.

PSY 571. Individual Intelligence Measurement**0-3**

Prerequisite: Psychology 570

A practicum in individual intelligence testing with emphasis on the Wechsler-Bellevue, Stanford-Binet, report writing, and case studies.

Mr. Corter.

PSY 576. Developmental Psychology**0-3**

Prerequisite: 9 hours in Psychology, including PSY 476 or PSY 475

A survey of the role of growth and development in human behavior; particularly of the child and adolescent periods. This course will pay particular attention to basic principles and theories in the area of developmental psychology.

Mr. Johnson, Miss Anderson.

PSY 578. Individual Differences**3-0**

Prerequisite: Six hours in Psychology

Nature, extent, and practical implications of individual differences and individual variation.

Mr. Barkley.

Courses for Graduates Only

PSY 604. Advanced Experimental Psychology: Learning and Motivation 3 or 3
Prerequisite: PSY 501 or equivalent

The objectives of this course are to promote familiarity with the kinds of research currently being conducted within the areas of "learning and motivation;" to foster effective performance in writing, speaking and reading in this area, in the derivation of hypotheses capable of experimental test and in the design of experiments to test them.

PSY 606. Behavior Theory 0-3
Prerequisite: PSY 200, a course in learning, Experimental Psychology and Statistics.

A study of the most fundamental considerations in behavior theory. Such topics as criteria of scientific meaningfulness, the nature of scientific explanation, the application of formal, logical techniques to theory analysis, the nature of probability, operationism, intervening variables, etc., will be covered. The aim of the course is to develop skill in handling theoretical concepts, the ability to analyze and evaluate theories, to deduce hypotheses from them, and to devise means of testing them.

Mr. Cook.

PSY 607. Advanced Industrial Psychology I 3-0
Prerequisite: 9 hours of Psychology and statistics or concurrent with statistics

Application of scientific methods to the measurement and understanding of industrial behavior.

Messrs. Drewes, Miller, Gray.

PSY 608. Advanced Industrial Psychology II 0-3
Prerequisite: PSY 607

Application of scientific methods to the measurement and understanding of industrial behavior.

Messrs. Drewes, Gray, Miller.

PSY 609. Psychological Clinic Practicum Maximum 9 hours
Prerequisite: 8 hours in Psychology

Clinical participation in interviewing, counseling, psychotherapy and administration of psychological tests. Practicum to be concerned with adults and children.

Mr. Corter.

PSY 610. Theories of Learning 0-3
Prerequisite: PSY 604

The objectives of this course are to promote learning of the theories currently used to explain how learning and forgetting occur so that testable consequences of these theories can be derived and so that the theories and their testable consequences are capably written and spoken about.

Mr. Newman.

PSY 612. Seminar in Industrial Psychology 3-3
Scientific articles, analysis of experimental designs in industrial psychology, and study of special problems of interest to graduate students in Industrial Psychology.

Graduate Staff.

PSY 613. Research in Psychology Credits by arrangements
Individual or group research problems; a maximum of six credits is allowed toward the Master's degree.

Graduate Staff.

PSY 635. Psychological Measurement 0-3
Prerequisites: Stat 511 or equivalent and 12 hours of Psychology

Theory of psychological measurement. Statistical problems and techniques in test construction.

Mr. Gary.

PSY 672. Personality Measurement 3-3
Prerequisites: PSY 570, PSY 571

Theory and practicum in individual personality testing of children and adults with emphasis on projective techniques, other personality measures, report writing and case studies.

Mr. Corter.

DEPARTMENT OF ELECTRICAL ENGINEERING**Graduate Faculty**

Professors: GEORGE BURNHAM HOADLEY, *Head*, WILLIAM JOHN BARCLAY, ARTHUR RAYMOND ECKELS, GEORGE EDWARD SCHAFER, WILLIAM DAMON STEVENSON, JR.

Associate Professors: NORMAN ROBERT BELL, EDWARD GEORGE MANNING, WILBUR CARROLL PETERSON

The Department of Electrical Engineering offers the Master of Science and the Doctor of Philosophy degrees. Graduate work in electrical engineering at the first-year or master's level is limited to one or two areas of specialization. In the more advanced study for the doctorate a comprehensive understanding of all fields of electrical engineering is required, and specialization appears in the research problem undertaken.

Advanced courses of a general and fundamental nature, such as electric network synthesis and electromagnetic waves, are recommended for all graduate students in electrical engineering, and are required of those who plan to carry their advanced studies to the level of the doctorate. Minor sequences of study in advanced mathematics or physics are planned to fit the needs of individual students.

Holders of graduate degrees in electrical engineering at North Carolina State College are in continual demand. Alumni hold important positions in the research laboratories of industry, government, and universities, in the teaching profession, and in the administrative and engineering departments of manufacturing corporations, utility companies, and government agencies.

Courses for Advanced Undergraduates

EE 401. Advanced Circuits and Fields **3-0**

Prerequisites: EE 302, MA 301

Required of seniors in EE

Transient analysis of electric circuits by the Laplace transform method, the study of transient and sinusoidal steady-state response in terms of poles and zeros of network functions. Staff.

EE 402. Advanced Circuits and Fields **0-3**

Prerequisites: EE 302, MA 301

Required of seniors in EE

A study of classical electric and magnetic field theory and its application to problems of electrical engineering. Consideration of electrostatics, radiation, and guided waves. Staff.

EE 411. Electrical Engineering Senior Seminar **1-0**

Prerequisite: Senior standing

Required of seniors in EE

Weekly meetings for the delivery and discussion of student papers on topics of current interest in Electrical Engineering. Staff.

EE 430. Essentials of Electrical Engineering **4-0**

Prerequisite: EE 301 or EE 332

Not available to undergraduates in electrical engineering

Essential theory of electric circuits, including electron tubes, solid state devices, transformers and rotating machines as needed to supply the electrical background for instrumentation and control theory. Intended primarily

for graduate students who do not have an electrical engineering undergraduate degree. Staff.

EE 431. Electronic Engineering

3-0

Prerequisites: EE 302, EE 314

Departmental elective for seniors

Comprehensive coverage of circuits and equipment using electronic devices; variable frequency effects; amplifiers, oscillators, modulators, detectors, wave-shaping circuits, generators of non-linear waveforms; basic pulse techniques; principles of electronic analogue computers. Emphasis on quantitative analysis and engineering design. Mr. Barclay.

EE 432. Communication Engineering

0-3

Prerequisite: EE 431

Departmental elective for seniors in EE

Application of electronic circuits and equipment to radio and wire communication systems. Elements of complete systems, wave propagation, antennas, transmitters, receivers, television, radar, electronic navigation systems, noise, special applications. Mr. Barclay.

EE 433. Electric Power Engineering

3-0

Prerequisites: EE 301, EE 305

Departmental elective for seniors in EE

A study of industrial power supply and power factor correction; direct and alternating current motor characteristics, starting methods, dynamic braking and speed control; motor applications, and industrial control apparatus. Mr. Bell.

EE 434. Power System Analysis

0-3

Prerequisites: EE 302, EE 305

Departmental elective for seniors in EE

Analysis of problems encountered in the long-distance transmission of electric power. Line parameters of the method of geometric mean distances. Circle diagrams, symmetrical components, and fault calculations. Elementary concepts of power system stability. Applications of digital computers to power-system problems. Mr. Stevenson.

EE 435. Elements of Control

3-0

Prerequisites: EE 314 and EE 305; or EE 430

Departmental elective for seniors in EE

Introductory theory of open and closed loop control. Functions and performance requirements of typical control systems and system components. Dynamic analysis of error detectors, amplifiers, motors, demodulators, analogue components and switching devices. Component transfer characteristics and block diagram representation. Mr. Peterson.

EE 438. Instrumentation in Nuclear Technology

0-3

Prerequisites: Either EE 430 or EE 301, EE 305 and EE 314; also, MA 301

Departmental elective for seniors in EE

Required course in Nuclear Engineering, Instrumentation Option curriculum
Radiation detectors, pulse amplifiers, pulse shapers, amplitude discriminators, counters, coincidence circuits. Mr. Manning.

EE 440. Fundamentals of Digital Systems

0-3

Prerequisite: EE 314 or EE 430

Departmental elective for seniors in EE

The basic theory of digital computation and control. Introduction to number systems, data handling, relay algebra, switching logic, memory circuits the application of electronic devices to switching circuits, and the design of computer control circuits. Mr. Bell.

Courses for Graduates and Advanced Undergraduates

EE 503. Linear Network Theory

3-0

Prerequisites: EE 302, 314, MA 301; B average in EE and MA

Analysis of linear networks, with emphasis on the system functions of the network in the frequency domain and response in the time domain.

Mr. Stevenson.

EE 506. Dynamical Analogies

0-3

Prerequisite: EE 301 or EE 331; EM 312 or EM 301; MA 301; B average in EE, EM and MA

A study of dynamic systems in various branches of engineering and science with emphasis on the similarities that exist among such integrated groups of devices. Analogous elements and quantities in these fields as determined from equations basic to each. Analytical formulation of system problems in acoustical, electrical, mechanical, and related fields and their solution by analog methods. Use of electronic analog computers for the solution of system problems.

Mr. Eckels.

EE 507. Electromagnetics

0-3

Prerequisites: EE 302, 314, MA 301; B average in EE and MA

Basic principles of electromagnetic field theory in vector analysis formulation, including static electric and magnetic fields, Maxwell's equations and applications to guided waves.

Staff.

EE 512. Communication Theory

0-3

Prerequisite: EE 431; B average in EE and MA

The frequency and time domain, modulation, random signal theory, autocorrelation, basic information theory, noise, communication systems.

Mr. Barclay.

EE 516. Feedback Control Systems

0-3

Prerequisites: EE 401, EE 435

Departmental elective for seniors in EE

Study of feedback systems for automatic control of physical quantities such as voltage, speed and mechanical position. Theory of regulating systems and servo-mechanisms. Steady state and transient responses. Evaluation of stability. Transfer function loci and root locus plots. Analysis using differential equation and operational methods. System and compensation and introduction to design.

Mr. Peterson.

EE 517. Control Laboratory

0-1

Corequisite: EE 516

Laboratory study of feedback systems for automatic control of physical quantities such as voltage, speed and mechanical position. Characteristics of regulating systems and servo-mechanisms. The laboratory work is intended to contribute to an understanding of the theory developed in EE 516, Feedback Control Systems.

Mr. Peterson.

EE 520. Fundamentals of Logic Systems

0-3

Prerequisite: EE 314 or EE 430

Boolean algebra, logic circuits, systematic minimization, block diagrams, logic systems in computers, diode and transistor logic, pulse operation, counters, multivibrators, cascaded systems, sequential systems.

Mr. Bell.

Courses for Graduates Only

EE 605, 606. Electrical Engineering Seminar

1-1

Prerequisite: Graduate standing in EE

A series of papers and conferences participated in by the instructional staff, invited guests, and students who are candidates for advanced degrees.

Mr. Eckels.

EE 611, 612. Electric Network Synthesis**3-3**

Prerequisite: EE 503

A study of modern network theory, with the emphasis on synthesis, based on the work of Brune, Bode, Guillemin Bott and Duffin, Darlington, Foster and many others. Both the realization problem and the approximation problem will be treated.

Mr. Hoadley.

EE 613. Advanced Feedback Control**0-3**

Prerequisite: EE 516

An advanced study of feedback systems for the control of physical variables. Analysis of follower systems and regulators. Mathematical and graphical description of systems. Stability theory and performance criteria. Frequency response and root locus methods of analysis. System compensation and design. Introductory analysis of non-linear systems.

Mr. Peterson.

EE 615. Electromagnetic Waves**4-0**

Prerequisite: EE 507

Maxwell's equations applied to a study of the propagation of energy by electromagnetic waves. Vector and scalar retarded potentials, propagation in free space and material media, guided electromagnetic waves, common waveguides, skin effects, resonant cavities. Microwave network theory applied to measurement problems.

Mr. Schafer.

EE 616. Microwave Electronics**0-4**

Prerequisite: EE 615

Frequency limitations of conventional electron tubes. Microwave power generation and control by interaction of electromagnetic fields with charged particles and molecular energy levels, and by non-linear reactances. Applications in klystrons, magnetrons, traveling-wave tubes, masers, and reactance amplifiers. Measurement problems and techniques in microwave region.

Mr. Barclay.

EE 617. Pulse Switching and Timing Circuits**0-3**

Prerequisites: EE 503, EE 512

Tube and transistor circuit techniques for the production, shaping, and control of nonsinusoidal wave forms. Fundamental circuits needed in pulse information systems, instrumentation, and computers.

Mr. Barclay.

EE 618. Antennas and Propagation**0-4**

Prerequisite: EE 615

Electromagnetic wave theory applied to antennas and antenna arrays with emphasis on microwave frequencies. Calculation and measurement of directional characteristics, gain, field intensity, propagation via the ionosphere over various terrains, obstacle gain, gain height theory, forward scatter and other topics.

Mr. Schafer.

EE 621. Electron Devices**0-3**

Prerequisite: EE 615

Internal operation of electron tubes and transistors; similarities and difference stressed. Electrical conduction through vacuum and semiconductors. Space charge, junction and diffusion effects. Characteristics of tubes and semiconductor devices at low frequencies and in various environments, parameters, and equivalent circuits of active devices.

Mr. Schafer.

EE 637. Circuit Analysis of Power Systems**3-0**

Prerequisite: EE 434

An advanced treatment of symmetrical components applied to unsymmetrical systems, and simultaneous faults.

Mr. Stevenson.

EE 638. Power System Stability**0-3**

Prerequisite: EE 434

A study of the principal factors affecting stability and of the method of making stability calculations. Illustrations of studies made on actual power systems.

Mr. Stevenson.

EE 641. Advanced Digital Computer Theory**0-3**

Prerequisite: EE 520

A study of the circuits and components of modern digital computers, including basic logic systems, codes, advanced systems of circuit logic, vacuum tube, transistor, and magnetic components. Memory devices, counters, converters, adders, accumulators, inputs, outputs, and computer control systems will be analyzed.

Mr. Bell.

EE 643. Advanced Electrical Measurements**0-2**

Prerequisites: EE 503, EE 431

A critical analysis of circuits used in electrical measurements, with special attention to such topics as balance convergence, effects of strays, sensitivity, the use of feedback in electronic devices, and automatic measuring systems.

Mr. Hoadley.

EE 645, 646. Advanced Electromagnetic Theory**3-3**

Prerequisites: EE 615 or PY 503; MA 512

A comprehensive study of electromagnetic theory with emphasis on field theory applications. Charges in both uniform and accelerated motion, field equivalence principles, anisotropic media, ferrite media, variational methods for waveguide discontinuities, periodic structures including Floquet's theorem, integral transform and function-theoretical techniques, solid state theory applied to quantum electronic devices.

Mr. Schafer.

EE 650. Electrical Engineering Research**Credits by arrangements**

Prerequisites: Graduate standing in EE, and approval of adviser.

Graduate Staff.

EE 661, 662. Special Studies in Electrical Engineering**3-3**

This course provides an opportunity for small groups of advanced graduate students to study, under the direction of qualified members of the professional staff, advanced topics in their special fields of interest.

Graduate Staff.

DEPARTMENT OF ENGINEERING MECHANICS**Graduate Faculty***Professors:* PATRICK HILL McDONALD, JR., *Head*, ADOLPHUS MITCHELL*Associate Professors:* DAVID MAURICE BENENSEN, ROBERT ALDEN DOUGLAS, NORMAN CLIFFORD SMALL, DANIEL SHOU-LING WANG

The Department of Engineering Mechanics offers graduate studies leading to the degree of Master of Science.

Studies in mechanics at the graduate level normally will include initial courses in the areas of both solids and fluids to augment contemporary offerings in continuum mechanics. These courses provide a background suitable for subsequent specialization in such fields as elasticity, plasticity, or vibrations in solid mechanics; ideal, viscous, or compressible fluid flow; as well as in the more generalized behavior of matter encountered in the study of rheology.

Recipients of advanced degrees in mechanics are in demand for research and development endeavors in the engineering field, in the establishments of both private industry and government. Increasing numbers of these men are choosing the opportunities afforded as members of the faculties of engineering schools and colleges.

Courses for Graduates and Advanced Undergraduates

EM 501, 502. Continuum Mechanics I, II

3-3

Prerequisites: EM 301; 303; ME 301; MA 405

The concepts of stress and strain are presented in generalized tensor form. Emphasis is placed on the discussion and relative comparison of the analytical models for a series of continua including the linear elastic solid, the perfect fluid and the viscous (Newtonian) fluid. The underlying thermodynamic principles are presented, the associated boundary value problems are formulated and selected examples are used to illustrate the theory.

Mr. Douglas.

EM 503. Theory of Linear Elasticity

3-0

Prerequisites: EM 301, MA 301

The differential equation approach employed in development of the equations representing the behavior of a linear elastic solid. The elastic problem formulated in two and three dimensions and various coordinate systems. Application of the theory illustrated through selected problems.

Mr. Douglas.

EM 504. Mechanics of Ideal Fluids

3-0

Prerequisites: EM 430 or EM 304; Corequisite MA 513

Basic equations of ideal fluid flow; potential and stream functions; vortex dynamics; body forces due to flow fields; methods of singularities in two-dimensional flows; analytical determination of potential functions; conformal transformations; free-streamline flows.

Mr. Lamb.

*EM 505. Mechanics of Viscous Fluids I

3-0

Prerequisites: EM 430 or EM 304; Corequisite MA 532

Equations of motion of a viscous fluid (Navier-Stokes Equations); general properties of the Navier-Stokes equations; some exact solutions of the Navier-Stokes equations; boundary layer equations; some approximate methods of solution of the boundary layer equations; laminar boundary layers in axi-symmetric and three-dimensional flows; unsteady laminar boundary layers.

Mr. Lamb.

**EM 506. Mechanics of Compressible Fluids I

3-0

Prerequisites: EM 430 or EM 304; ME 302; Corequisite MA 532

Introduction to compressible fluid flow; isentropic, one-dimensional flow; Rayleigh and Fanno line flows; generalized one-dimensional flow; normal shock waves; introduction to multi-dimensional, compressible flow.

Mr. Edwards.

**EM 507. Systems Analysis

3-0

Prerequisites: EM 301; 303; MA 511

A course in the design of engineering systems in which mechanics dominates.

Mr. McDonald.

**EM 508. Systems Synthesis

0-3

Prerequisites: EM 507

A course in the design of engineering systems in which mechanics dominates.

Mr. McDonald.

*EM 509. Space Mechanics I

3-0

Prerequisites: EM 302; EM 304; Corequisite MA 511

The application of mechanics to the analysis and design of orbits and trajectories. Trajectory computation and optimization; space maneuvers; re-entry trajectories; interplanetary guidance.

Mr. Clayton.

*EM 510. Space Mechanics II.

0-3

Prerequisites: EM 509; MA 511

Continuation of EM 509. The analysis and design of guidance systems. Basic

* Offered in 1962-63 and alternate years.

** Offered in 1963-64 and alternate years.

sensing devices; the characteristics of an inertial space; the theory of stabilized platforms; terrestrial inertial guidance. Mr. Clayton.

***EM 511. Theory of Plates and Shells**

3 or 3

Prerequisites: EM 301 accompanied by MA 511

A modern study of the theory of plates and shells. Topics are selected from problems involving membranes, folded plates, circular and rectangular slabs, domes, cylindrical shells and hyperbolic paraboloids. Solutions are obtained by both classical and modern numerical methods. Mr. Wang.

****EM 551. Advanced Strength of Materials**

0-3

Prerequisite: EM 301

Stresses and strains at a point; rosette analysis; stress theories, stress concentration and fatigue; plasticity; inelastic, composite and curved beams; prestress energy methods; shear deflections; buckling problems and column design; and membrane stresses in shells. Mr. Mitchell.

****EM 552. Elastic Stability**

0-3

Prerequisites: MA 301; MA 405; EM 551

A study of elastic and plastic stability. The stability criterion as a determinant. The energy method and the theorem of stationary potential energy. The solution of buckling problems by finite differences and the calculus of variations. The application of successive approximations to stability problems. Optimization applied to problems of aeroelastic and civil engineering structures. Mr. Mitchell.

****EM 555. Dynamics I**

0-3

Prerequisites: EM 301; MA 405

The theory of vibrations from the Lagrangian formulation of the equations of motion. Free and forced vibrations with and without damping, multiple degrees of freedom, coupled motion, normal mode vibrations, wave propagation in solid bodies. Mr. Clayton.

****EM 556. Dynamics II**

0-3

Prerequisites: EM 301; MA 405

The dynamics of particles and rigid bodies by the use of formulations of the laws of mechanics due to Newton, Euler, Lagrange, and Hamilton. Accelerated reference frames, constraints, Euler's angles, the spinning top, the gyroscope, precession, stability, phase space, and nonlinear oscillatory motion. Mr. Clayton.

Courses for Graduates Only

****EM 601, 602. Unifying Concepts in Mechanics I, II**

3-3

Prerequisite: PY 601

Generalized treatment of the fundamental equations and boundary value problems of continuous and non-continuous media. Use is made of contemporary developments in irreversible thermodynamics, statistical mechanics, and electrodynamics to provide a unified foundation for the development of principles governing the dynamic and thermodynamic behavior of elastic, plastic and visco-elastic solids, viscous fluids and rheological media.

Mr. McDonald.

****EM 604. Theory of Plasticity**

0-3

Prerequisite: MA 503

Development of the equations representing the plastic behavior of deformable solids. Yield conditions and plastic stress-strain relations. Plane strain theory, hyperbolic equations and slip line fields. Selected problems to illustrate the theory. Mr. Douglas.

* Offered in 1962-63 and alternate years.

** Offered in 1963-64 and alternate years.

EM 605. Plastic Limit Analysis*0-3**

Prerequisite: EM 503

Determination of the load carrying capacity of perfectly plastic structures including frames, plates, and shells. Emphasis on the underlying principles and general methods of analysis for bodies involving three-dimensional states of stress.

Graduate Staff.

****EM 611. Mechanics of Compressible Fluids II****0-3**

Prerequisite: EM 506

Continuation of EM 506; linearized theory of two-dimensional, flow; method of characteristics for two-dimensional supersonic flow; oblique shock waves; unsteady one-dimensional flow; shock-wave boundary layer interactions; transonic flow.

Mr. Edwards.

EM 612. Mechanics of Viscous Fluids II*0-3**

Prerequisite: EM 505

Continuation of EM 505; phenomenological theories of turbulence; turbulent flow in ducts and pipes; turbulent boundary layer with and without pressure gradient; compressible boundary layer; boundary layer control; free viscous flow.

Mr. Lamb.

EM 695. Experimental Methods in Mechanics**0-3**

Prerequisites: Consent of Instructor

The study of specialized experimental techniques utilized in contemporary research in the areas of Mechanics.

Graduate Staff.

EM 697. Seminars in Mechanics**1 to 3**

Prerequisites: Graduate standing and consent of adviser, required

The discussion and development of theory relating to contemporary research in the frontier areas of Mechanics.

Graduate Staff.

EM 698. Special Topics in Mechanics**3 to 9**

The study, by small groups of graduate students under the direction of members of the faculty, of topics of particular interest in various advanced phases of Mechanics.

Graduate Staff.

EM 699. Research in Mechanics**3 to 6**

Individual research in the field of Mechanics.

Graduate Staff.

DEPARTMENT OF ENTOMOLOGY**Graduate Faculty**

Professors: CLYDE F. SMITH, *Head*, THOMAS G. BOWERY, DAVID A. YOUNG, JR.

Professor Emeritus: T. B. MITCHELL

Associate Professors: CHARLES H. BRETT, MAURICE H. FARRIER, FRANK E.

GUTHRIE, WALTER JOSEPH MISTRIC, ROBERT L. RABB

Assistant Professors: WILLIAM V. CAMPBELL, ERNEST HODGSON, HERBERT H.

NEUNZIG, WILLIAM A. STEPHEN

The Department of Entomology offers graduate work leading to the Master of Science and Doctor of Philosophy degrees. The work in entomology is well supported by strong departments in chemistry, statistics, and the plant and animal sciences.

Excellent facilities for advanced study and research are provided in a modern building designed for the use of the biological sciences. Equipment includes modern greenhouses, air-conditioned laboratories with precision temperature and humidity control, spray chambers, dust towers, low temper-

* Offered in 1962-63 and alternate years.

** Offered in 1963-64 and alternate years.

ature rooms, and pesticide residue laboratories. Facilities are provided to support research in insect toxicology, insect physiology, insect biochemistry, biology, ecology, and taxonomy.

The well-trained faculty teaches the specialized courses in the various phases of advanced entomological work.

Opportunities for employment of well-trained entomologists are plentiful and varied. Research and teaching opportunities exist in many State institutions. Federal agencies offer positions in control, research, and regulatory work. Private industry is using more and more entomologists in the development, production, control testing and sale of agricultural chemicals. Jobs as consultants in domestic or foreign service as well as in private business and sales are available. Also, a person can go into business for himself as a pest control operator or as an insecticide formulator.

Courses for Graduates and Advanced Undergraduates

ENT 501-502. Insect Morphology

3-3

Prerequisite: ENT 301 or 312

Covers general morphology, external and internal, of the insects and their relatives. Ent. 501 will deal primarily with external morphology and Ent. 502 with internal morphology. (Will be offered 1963-64 and alternate years.)

Mr. Young.

ENT 506. Chemistry of Insecticides

0-3

Prerequisite: ENT 312, CH 203

A study of the critical chemical, physical, and biological properties of compounds used for insect control. This course is directed toward obtaining fundamental knowledge of the scientific principles underlying modern methods of plant protection including details of actual methods of insecticide application. (Will be offered 1963-64 and alternate years.)

Mr. Guthrie.

ENT 511. Systematic Entomology

3-0

Prerequisite: ENT 301 or 312

A somewhat detailed survey of the orders and families of insects, designed to acquaint the student with these groups and develop in the student some ability in the use of keys, descriptions, etc. (Will be offered 1963-64 and alternate years.)

Mr. Young.

ENT 531. Insect Ecology

3-0

Prerequisite: ENT 301 or 312 or equivalent

The influence of environmental factors on insect development, distribution, and abundance. (Will be offered 1963-64 and alternate years.)

Mr. Rabb.

ENT 541. Immature Insects

4-0

Prerequisite: ENT 301 or 312 or equivalent

A study of the characteristics of the immature forms of the orders and principal families of insects. (Will be offered 1962-63 and alternate years.)

Messrs. Rabb and Neunzig.

ENT 551, 552. Applied Entomology

3-3

Prerequisite: ENT 301 or 312

An advanced course in which the principles of applied entomology are studied in respect to the major economic insect pests. Methods of determining and examining insect damage, the economic importance of insects, and the chief economic pests of man, food, and fiber are studied as well as laws and regulations pertaining to insects and insecticides. (Will be offered 1962-63 and alternate years.)

Mr. Mistic.

- ENT 561. Literature and History of Entomology** **3-0**
 Prerequisite: ENT 301 or 312 or equivalent
 A general course intended to acquaint the student with literature problems of the scientist, mechanics of the library and book classification, bibliographies of the zoological sciences, abstract journals, forms of bibliographies, forms of literature, preparation of scientific papers; taxonomic indexes and literature (with a historical background) and history of the development of zoological science from ancient to modern times with emphasis on entomology. (Will be offered 1963-64 and alternate years.) Mr. Farrier.
- ENT 571. Forest Entomology** **3-0**
 Prerequisite: ENT 301 or 312
 A study of methods of identification of forest pests, the factors governing their abundance habits, and control. (Will be offered 1963-64 and alternate years.) Mr. Farrier.
- ENT 582. (ZOO 592) Medical and Veterinary Entomology (Parasitology)** **0-3**
 Prerequisite: ENT 301 or ENT 312
 A study of the morphology, biology and control of the parasitic arthropods of man, domestic and wild animals. (Will be offered 1963-64 and alternate years.) Messrs. Harkema and Farrier.
- ENT 590. Special Problems** **Credits by arrangement**
 Prerequisites: Graduate Standing and Consent of the Instructor
 Original research on special problems in entomology not related to a thesis problem, but designed to provide experience and training in research. Graduate Staff.
- ENT 592. Acarology** **0-3**
 Prerequisite: ENT 301 or 312, or ZO 103
 A systematic survey of the mites and ticks with emphasis on identification, biology and control of the more common and economic forms attacking material, plants and animals including man. (Will be offered 1962-63 and alternate years.) Mr. Farrier.

Courses for Graduates Only

- ENT 602. Principles of Taxonomy** **0-3**
 Prerequisite: ENT 511
 A course introducing the methods and tools used in animal taxonomy, designed to promote a better understanding of taxonomic literature, and provide a foundation for taxonomic research. (Will be offered 1962-63 and alternate years.) Mr. Young.
- ENT 611. Insect Physiology** **4-0**
 Prerequisite: ENT 312, ENT 502, CH 451, or equivalent
 The course deals with the physiology and biochemistry of insects. The function of the different organ systems and the intermediary metabolism of insects will be considered. Laboratory work will include techniques of current importance in physiological research. (Will be offered 1962-63 and alternate years.) Mr. Hodgson.
- ENT 622. Insect Toxicology** **0-4**
 Prerequisite: ENT 312, CH 426 or equivalent
 The course deals with the relationship of chemical structure to toxicity in insects. The biochemical mechanisms involved in toxication and de-toxication will be stressed as well as physiological explanation of the chemical poisoning of insects. The biochemical, behavioral, and morphological explanation of resistance to insecticides will be studied. Laboratory work involves cholinesterase inhibition, dehydrochlorination of DDT by resistant houseflies, comparative toxicity of insecticides, and bioassay methods. (Will be offered 1962-63 and alternate years.) Mr. Guthrie.

ENT 680. Seminar

1-1

Prerequisite: Graduate standing in Entomology or closely allied fields.

Discussion of entomological topics selected and assigned by Seminar Chairman.
Graduate Staff.**ENT 690. Research****Credits by arrangement**

Prerequisite: Graduate standing in Entomology or closely allied fields.

Original research in connection with thesis problem in entomology.

Graduate Staff.

DEPARTMENT OF EXPERIMENTAL STATISTICS**Graduate Faculty**

Professors: JACKSON ASHCRAFT RIGNEY, *Head*, RICHARD LOREE ANDERSON, *Graduate Administrator*, COLUMBUS CLARK COCKERHAM, ARNOLD HERBERT EDWARD GRANDAGE, ROBERT JOHN HADER, HENRY LAURENCE LUCAS, JR., DAVID DICKENSON MASON, ROBERT JAMES MONROE,* ROBERT GEORGE DOUGLAS STEEL

Professor Emeritus: GERTRUDE MARY COX

Adjunct Professors: WILLIAM STOKES CONNOR, ALVA LEROY FINKNER

Associate Professors: WILLIAM JACKSON HALL, JOHN CLEMENT KOOP, FRANCIS EDWARD McVAY, ROGER GENE PETERSEN, CHARLES HARRY PROCTOR, WILLIAM WESLEY GARRY SMART, JR., HUBERTUS ROBERT VAN DER VAART

Assistant Professors: JOHN OREN RAWLINGS, THOMAS DUDLEY WALLACE

The Department of Experimental Statistics offers work leading to the Master of Science and Doctor of Philosophy degrees. This department has a working arrangement with the Department of Biostatistics in the University of North Carolina's School of Public Health at Chapel Hill, whereby the graduate students can major in experimental statistics and minor in the Division of Health Affairs. The Department of Experimental Statistics maintains a close liaison with the Department of (mathematical) Statistics at Chapel Hill in order to strengthen the offerings in statistical theory. (See University of North Carolina courses listed below.) Introductory courses of these two departments are coordinated so that it is easy for a beginning statistics graduate student to transfer from one institution of the Consolidated University to another. Both departments are affiliated with the Institute of Statistics (See page 9).

The department has at least one staff member who consults with researchers in each of the following fields and who conducts his own research on statistical problems which are encountered: the various agricultural sciences, quantitative genetics, industry and engineering, physical sciences, and social problems. In addition, there is active research in the general fields of experimental design and sample surveys.

A graduate student who majors in experimental statistics may specialize in any one of these fields with his minor in the associated department; or with a strong mathematical background he may prefer to minor in mathematics or mathematical statistics. For the graduate student who wishes to minor in statistics, the department has developed a curriculum tailored to

* On leave, 1961-1962

his needs. Many employers are offering added inducements for research personnel who have such a minor. The department cooperates with other graduate departments in order to provide the type of courses needed for their students and to provide a staff to participate in their graduate programs.

In addition to its consulting services, the department provides a computing service for the Agricultural Experiment Station and for other research departments on the campus and in the State. It furnishes several federal agencies and private concerns with research and consulting services on a contract basis. This work supplies live problems on which graduate students may acquire experience and maturity.

A program of training in biomathematics at the doctoral and postdoctoral levels recently has been initiated in the Department of Experimental Statistics. This program requires that the student become well-grounded in four areas—mathematics, statistics, physical science, and some phase of biology. Several assistantships are available for doctoral students and several fellowships for post-doctorals. Mathematical biology and related areas are now developing rapidly and there is much opportunity for properly trained people.

The Department of Experimental Statistics is located in Patterson Hall, adjacent to the D. H. Hill Library, which has copies of important statistical books and periodicals. The reprint files of several staff members are available for the use of graduate students. Facilities of the Computing Center, which include an IBM 650 electronic digital computer, are used for research and instruction; automatic desk calculators are also available.

The department has approximately twenty graduate assistantships at stipends adjusted to the previous training and experience of the recipients.

Most fields of research, development, production, and distribution are seeking persons trained in statistical theory and methods. The demand is equally strong from universities, agricultural and engineering experimental stations, national defense agencies, other federal agencies, and a wide variety of industrial concerns. There is a need for experimental statisticians with the master's degree as well as for those with the doctorate.

At the request of the Southern Regional Education Board's Advisory Commission on Statistics, Virginia Polytechnic Institute, Oklahoma State University, the University of Florida, and North Carolina State College have joined in a continuing program of graduate summer sessions in statistics, held at the four institutions in rotation. In 1962 the host institution is Oklahoma State University, followed by North Carolina State College and the University of Florida. Each of the sponsoring institutions will accept the credits earned by students in the summer sessions as residence credit. The courses are arranged to provide consecutive work in successive summers. Information regarding these courses may be obtained from any of the cooperating statistical departments or the deans of the Graduate Schools.

Courses for Advanced Undergraduates

ST 421, 422. Introduction to Mathematical Statistics

3-3

Prerequisite: MA 202 or MA 212

Elementary mathematical statistics primarily for students not intending to take further work in theoretical statistics. Includes introduction to probabili-

ty, common theoretical distributions, moments, moment generating functions, sampling distributions, (F, t, chi-square), elementary estimation and hypothesis testing concepts, bivariate distributions, simple and multiple linear regression, analysis of variance, and elementary design of experiments. Staff.

Courses for Graduates and Advanced Undergraduates

ST 501, 502. Basic Statistical Analysis 3-3

Prerequisite: ST 311 or equivalent or graduate standing

Basic concepts of statistics; random variables, distributions, statistical measures, estimation, tests of significance, analysis of variance, elementary design and sampling, factorial experiments, multiple regression, analysis of discrete data, and other topics. Intended primarily for statistics majors and Ph.D. minors and not intended as a service course for other departments.

Mr. Steel.

†*ST 511. Experimental Statistics for Biological Sciences I 3-3

Prerequisites: ST 311 or graduate standing

Basic concepts of statistical models and use of samples; variation, statistical measures, distributions, tests of significance, analysis of variance and elementary experimental design, regression and correlation, chi-square.

Messrs. Monroe, Rawlings.

†*ST 512. Experimental Statistics for Biological Sciences II 3-3

Prerequisite: ST 511 or equivalent

Covariance, multiple regression, factorial experiments, individual degrees of freedom, incomplete block designs, experiments repeated over space and time.

Mr. Mason.

ST 513. Experimental Statistics for Social Sciences I 3-0

Prerequisite: ST 311 or graduate standing

Basic concepts in collection and analysis of data. Variability of sample data, distributions, confidence limits, chi-square, t-test, analysis of variance, regression, correlation, analytic and descriptive surveys, experimental designs, index numbers.

Mr. McVay.

ST 514. Experimental Statistics for Social Sciences II 0-3

Prerequisite: ST 513 or equivalent

Extension of basic statistical concepts to social experiments and surveys; sampling from finite populations and estimating using unrestricted, stratified, systematic, and multistage selections; analysis of variance continued; multiple regression; covariance; experimental designs.

Mr. Proctor.

†ST 515, 516. Experimental Statistics for Engineers 3-3

Prerequisite: ST 361 or graduate standing

General statistical concepts and techniques useful to research workers in engineering, textiles, wood technology, etc. Probability, distributions, measurement of precision, simple and multiple regression, tests of significance, analysis of variance, enumeration data, sensitivity data, life testing experiments and experimental design.

Mr. Hader.

†*ST 521. Basic Statistical Inference 0-3

Prerequisites: MA 522 and MA 511

Frequency distributions and moments; sampling distributions; introductory theory of point and interval estimation; tests of hypotheses.

Mr. Grandage.

† Offered in special summer session, 1963.

* Offered in special summer session at Oklahoma State University (1962).

- †***ST 522. Basic Theory of Least Squares and Variance Components** 3-0
 Prerequisites: ST 521 and MA 405
 Theory of least squares; multiple regression; analysis of variance and covariance; experimental design models; factorial experiments; variance component models. Mr. Anderson.
- ST 591. Special Problems** 1 to 3—1 to 3
 Development of techniques for specialized cases, particularly in connection with thesis and practical consulting problems. Graduate Staff.
- U.N.C. ST 111. Methods of Mathematical Statistics I**
 Prerequisite: Advanced Calculus
 Introductory treatment of special mathematical techniques of particular importance in probability and statistics, including topics from combinatorial mathematics, Fourier and LaPlace transforms, contour integration, special inequalities and finite differences. Mr. Smith.
- U.N.C. ST 131. Elementary Probability** 3-0
 Prerequisite: Advanced Calculus
 Logical foundations and axiomatic treatment of probability, conditional probability, additive and multiplicative laws, Bayes' theorem and inverse probability, binomial and Poisson distributions, moments and moment generating functions, law of large numbers and central limit theorem, convolution of distributions. Mr. Hall.
- U.N.C. ST 132. Intermediate Probability** 0-3
 Prerequisite: U.N.C. ST 131 or 134
 Laws of large numbers, characteristic functions, and central limit theorems. Elements of stochastic processes and their applications, including random walks, Markov chains, recurrent events, Brownian motion, and elementary queuing theory. Mr. Smith.
- U.N.C. ST 133. Least Squares and Time Series** 3-0
 Prerequisites: U.N.C. ST 134 and Matrix Algebra
 The classical method of least squares with modern improvements and developments, interpretations of the results in terms of probability, applications to social and to natural sciences, the problem of observations ordered in time, correlation and regression of time series, seasonal variation and secular trends, methods of correcting for lack of independence and of avoiding fallacies. Mr. Hotelling.
- U.N.C. ST 134. Statistical Theory I** 5-0
 Prerequisite: Advanced Calculus
 Relative-frequency and axiomatic definitions of probability. The concept of a random sample. Additive and multiplicative laws. Univariate and multivariate, marginal and conditional distributions. Discrete and continuous cases. Moments, cumulants, generating functions. Transformation of variables. Introduction to tests of simple hypotheses and interval estimates. Model building. Special distributions: binomial, Poisson, normal, etc. Law of large numbers. Central limit theorem. Order statistics. Multinomial distribution theory. Chi-square. Mr. Hall.
- U.N.C. ST 135. Statistical Theory II** 0-3
 Prerequisite: U.N.C. ST 134
 Distributions of functions of random normal samples. F and t distributions. Point estimation. Properties of estimators, maximum likelihood. Information. Cramér-Rao inequality. Interval estimation. Neyman-Pearson tests of hypotheses. Likelihood ratio tests. Contingency tables. Chi-square tests of goodness of fit. Elements of decision theory and sequential and non-parametric inferences. Mr. Hall.

† Offered in special summer session, 1963.

* Offered in special summer session at Oklahoma State University (1962).

U.N.C. ST 144. Correlation, Contingency, and Chi Tests 0-3

Prerequisite: U.N.C. ST 135; Corequisite: Matrix Algebra

Elements of the theory of testing composite hypotheses. Multivariate normal populations, total, partial and multiple correlations. Singular multivariate distributions. Tests of independence, homogeneity, and goodness of fit. Contingency tables; exact tests for independence and the chi approximation. Many-dimensional contingency tests. Mr. Hotelling.

U.N.C. ST 150. Analysis of Variance with Application to Experimental Designs 0-3

Prerequisite: Matrix Algebra; Corequisite: U.N.C. ST 135

Unified mathematical theory for the analysis of data from experimental designs. Applications to lattice designs, balanced and partially balanced incomplete block designs, Latin and Youden squares; modification for missing plots; intra-block and inter-block analysis; split plot and factorial designs; analysis of factorial designs in the case of total or partial confounding; use of concomitant information; analysis of covariance with the general linear model; analysis of multiple classified data with unequal numbers in different cells; general theory of components of variance including mixed models; principles guiding the selection of a design. Mr. Bose.

U.N.C. ST 182. Mathematical Economics 3-0

Prerequisite: Advanced Calculus; Corequisite: Matrix Algebra

Perfect and imperfect competition, monopoly, utility vs. ranking of preferences, relations between commodities, general equilibrium, effects of taxes and controls of various kinds, index numbers. Mr. Hotelling.

Offered in fall of 1962-1963 and alternate years.

U.N.C. ST 183. Advanced Mathematical Economics 0-3

Prerequisites: U.N.C. ST 182 and Differential Equations

Dynamic variations in the economy; calculus of variations and stochastic process theory with applications to economic problems; valuation, depreciation, and depletion; most profitable rates of exploitation of mineral and biological resources. Mr. Hotelling.

Offered in spring of 1962-1963 and alternate years.

U.N.C. ST 197. Population Statistics 0-3

Prerequisite: Permission of instructor

Training in techniques for quantitative research with population data. Composition characteristics, population estimates, computation and standardization of birth and death rates, construction and application of life tables, measurement of migration. Mr. Price.

Courses for Graduates Only**ST 611, 612. Intermediate Statistical Theory 3-3**

Prerequisites: ST 521, MA 512 and MA 405

This course will provide the additional theory, above that of ST 521, needed for many advanced theory courses. Many of the topics of ST 521 will be developed more rigorously, with more attention paid to mathematical aspects. Advanced probability theory; limit theorems, distribution theory, multinormal distributions. Statistical decision theory, theory of estimation, confidence regions, theory of tests of hypotheses, sequential tests, non-parametric methods. Mr. Hall.

ST 621. Statistics in Animal Science 3-0

Prerequisite: ST 502 or equivalent

Sources and magnitude of errors in experiments with animals, experimental designs and methods of analysis adapted to specific types of animal research, relative efficiency of alternate designs, amount of data required for specified accuracy, student reports on selected topics. Mr. Lucas.

Offered in fall of 1963-1964 and alternate years.

ST 622. Principles of Biological Assays

(See AI 622)

ST 623. Statistics in Plant Science**3-0**

Prerequisite: ST 502 or equivalent

Principles and techniques of planning, establishing, and executing field and greenhouse experiments. Size, shape and orientation of plots; border effects; selection of experimental material; estimation of size of experiments for specified accuracy; scoring and subjective tests; subsampling plots and yields for laboratory analysis.

Mr. Mason.

ST 626. Statistical Concepts in Genetics**0-3**

Prerequisite: Genetics 512; Corequisite: ST 502 or equivalent

Factors bearing on rates of change in population means and variances, with special reference to cultivated plants and domestic animals; selection, inbreeding, magnitude and nature of genotypic and non-genotypic variability; experimental and statistical approaches in the analysis of quantitative inheritance.

Mr. Cockerham.

†*ST 631. Theory of Sampling Applied to Survey Design**3-0**

Prerequisite: ST 422; ST 502 or equivalent

Basic theory of sampling from a finite population. Confidence limits and estimation of optimum sample size, comparison of different sample designs, methods and probabilities for selection and methods of estimation, choice of a sampling unit, double sampling, matched samples.

Messrs. Proctor, Koop.

ST 641. (RS 641). Statistics in Sociology**3-0**

Prerequisite: ST 513 or equivalent

The application of statistical methods in sociological research. Emphasis on selecting appropriate models, instruments and techniques for the more frequently encountered problems and forms of data

Mr. Hamilton.

ST 651. (AGC 651) Econometric Methods I**3-0**

Prerequisites: ST 421; ST 502 or equivalent; AGC 641

The role and uses of statistical inference in agricultural economic research; measurement problems and their solutions arising from the statistical model and the nature of the data; limitations and interpretation of results of economic measurement from statistical techniques. Topics include the problems of specification, aggregation, identification, multicollinearity and autocorrelation. Attention also is given to expectations models and simultaneous stochastic equations.

Mr. Wallace.

ST 652. (AGC 652) Econometric Methods II**0-3**

Prerequisites: ST 422 and AGC 551

Techniques for problem analysis in agricultural economics; attention to analysis of time series data; non-parametric inference; experimental design in economic research; estimation of parameters in production functions and in simultaneous models; selected special topics.

Mr. Anderson.

ST 661. Advanced Special Problems**1 to 3—1 to 3**

Prerequisites: ST 502 or equivalent; ST 522

Any new advance in the field of statistics which can be presented in lecture series as unique opportunities arise, including (a) theory of sampling applied to survey design and (b) analysis of messy data.

Graduate Faculty, Visiting Professors.

†ST 671. Advanced Topics in Least Squares and Variance Components**0-3**

Prerequisites: ST 502 or equivalent; ST 522

Use of non-balanced designs to estimate variance components; comparison of estimators; problems with finite populations. Least squares procedures for

† Offered in special summer session, 1963.

* Offered in special summer session at Oklahoma State University (1962).

non-standard conditions; unequal variances, correlated errors, non-additivity, measurement errors, non-normality. Functional relationships. Factorial experiments with continuous factor levels; incomplete blocks.

Mr. Anderson.

ST 672. Special Advanced Topics in Statistical Analysis **3-0**

Prerequisites: ST 502 or equivalent; ST 522

Enumeration data; covariance; non-linear models; discriminant functions and other multivariate techniques.

Mr. Monroe.

ST 674. Advanced Topics in Construction and Analysis of Experimental Designs **0-3**

Prerequisites: ST 502 or equivalent; ST 522

Inter-block analysis of incomplete blocks designs, partially balanced designs, confounding, data collected at several places and times, multiple factor designs, change-over trials, analysis of groups of means.

Graduate Staff.

ST 681. Seminar **1-1**

A maximum of two credits is allowed toward the master's degree, but any number toward the doctorate.

Graduate Staff.

ST 691. Research **Credits by arrangement**

A maximum of nine credits is allowed toward the master's degree; no limitation on credits in doctorate programs.

Graduate Staff.

U.N.C. ST 200. Applied Multivariate Analysis I **3-0**

Prerequisite: U.N.C. ST 135

The general multivariate model for experimental work; relations between multiple regression, analysis of variance and multivariate analysis; factor analysis; the generalized variance; the generalized Student ratio; intraclass correlations; testing compound symmetry between two sample covariance matrices; scale analysis; canonical correlation, testing for the rank of correlation matrix.

Mr. Nicholson.

Offered in fall of 1962-1963 and alternate years.

U.N.C. ST 202. Methods of Operations Research **3-0**

Prerequisite: U.N.C. ST 135

Linear programming, theory of games, techniques for analyzing waiting lines and queues; applied probability; recent developments, applications of results to specific problems; case studies.

Mr. Nicholson.

U.N.C. ST 204. Selected Techniques of Approximation **3-0**

Prerequisite: Advanced Calculus

The methods of steepest descent and other methods of approximating integrals with special attention to integrals occurring in probability and statistics; asymptotic series; large-sample approximations; orthogonal polynomials and their applications to numerical quadrature, interpolation and moment problems.

Mr. Hotelling.

Offered in fall of 1963-1964 and alternate years.

U.N.C. ST 212. Methods of Mathematical Statistics II **0-3**

Prerequisite: Advanced Calculus

Measure and integration theory, with special reference to random variables, distribution functions, and probability measures, and including Fubini's Theorem, the Radon-Nikodym Theorem, conditional probability, conditional expectation, and models of convergence.

Messrs. Hall, Smith.

U.N.C. ST 220. Theory of Estimation and Hypothesis Testing **4-0**

Prerequisites: U.N.C. ST 132, 135 and 212

Sufficient statistics. Unbiased estimates with minimum variance. Properties of tests—power, similarity, unbiasedness, sampling economy, etc. Admissible, Bayes and minimax estimates and tests. Invariance. Large sample theory. Confidence sets. Multi-decision problems.

Mr. Hoeffding.

U.N.C. ST 221. Sequential Analysis**2-0**

Prerequisites: U.N.C. ST 132 and 135

Estimation and testing when the sample size depends on the observations. Double sampling. Inverse sampling. Sequential probability ratio tests. Stochastic approximation methods.

Mr. Hoeffding.

U.N.C. ST 222. Nonparametric Inference**0-3**

Prerequisites: U.N.C. ST 132, 135 and 212

Estimation and testing when the functional form of the population distribution is unknown. Rank and sign tests, tests based on permutations of observations, power of nonparametric tests, optimum nonparametric tests and estimators, nonparametric confidence intervals and tolerance limits.

Mr. Hoeffding.

U.N.C. ST 231. Advanced Probability**3-0**

Prerequisites: U.N.C. ST 132 and 212

Advanced theoretic course, including: random variables and expectations, distributions and characteristic functions, infinitely divisible distributions, central limit theorems, laws of large numbers, and stable laws.

Offered in fall of 1962-1963 and alternate years.

Mr. Smith.

U.N.C. ST 232. General Theory of Statistical Decision**0-3**

Prerequisites: U.N.C. ST 135 and 212

Selected topics in the general theory of statistical decisions, based on the work of Abraham Wald.

Mr. Hoeffding.

Offered in spring of 1962-1963 and alternate years.

U.N.C. ST 235. Stochastic Processes**0-3**

Prerequisites: U.N.C. ST 132 and 212

Advanced theoretic course, including: separability of a process, processes with orthogonal random variables, Markov processes, martingales, and processes with independent increments.

Messrs. Smith and Hoeffding.

Offered in spring of 1963-1964 and alternate years.

U.N.C. ST 237. Time Series Analysis**0-3**

Prerequisite: U.N.C. ST 133

Analysis of data involving trends, seasonal variations, cycles and serial correlations; periodograms and correlograms; exogenous and endogenous cycles; stochastic difference equations; tests for randomness; distributions of serial correlation coefficients; the sinusoidal limit theorem.

Mr. Hotelling.

Offered in spring of 1963-1964 and alternate years.

U.N.C. ST 251. Combinatorial Problems of the Design of Experiments**3-0**

Prerequisite: U.N.C. ST 150

Application of methods of modern algebra and finite geometry to problems arising in the design of experiments. Construction of orthogonal sets of Latin squares, construction of balanced and partially balanced designs, proofs of non-existence of certain classes of designs, construction of confounded factorial designs, fractional replications, orthogonal arrays and multifactorial designs.

Mr. Bose.

U.N.C. ST 252. Information Theory**0-3**

Prerequisite: U.N.C. ST 132; Corequisite: U.N.C. ST 212

Introductory concepts. Entropy fundamental inequalities. The noiseless coding theorem. Transmission rate and channel capacity. Decision schemes and data processing. The coding theorem for discrete channels without memory. The semicontinuous channel without memory and the corresponding coding theorem. Coding theorem for the discrete channel with memory. The binary symmetric channel.

Mr. Bose.

U.N.C. ST 260. Multivariate Analysis**3-0**

Prerequisites: U.N.C. ST 135 and Matrix Algebra

Tests and confidence intervals in multivariate analysis of variance, associa-

tion between subsets of a multivariate normal set, the rank of a matrix, factor analysis.

Mr. Roy.

U.N.C. ST 261. Advanced Multivariate Analysis

0-3

Prerequisite: U.N.C. ST 260

Distribution problems connected with the tests and confidence intervals discussed in ST 260; the power functions of the tests and the shortness of the confidence intervals against different classes of alternatives; some applications, especially to problems in sociology, psychology and anthropology.

Mr. Roy.

U.N.C. ST 300-301. Seminar in Statistical Literature

1-1

Prerequisite: A course requiring U.N.C. ST 135 as prerequisite

Graduate Staff.

U.N.C. ST 310-311. Seminar in Theoretical Statistics

3-3

Prerequisite: A course requiring U.N.C. ST 135 as prerequisite

Graduate Staff.

U.N.C. ST 321-322. Special Problems

3-3

Statistical theory of multi-factor and multi-response experiments with responses not necessarily "normal."

Mr. Roy.

DEPARTMENT OF FOOD SCIENCE

Graduate Faculty

Professors: WILLIAM MILNER ROBERTS, *Head*, LEONARD WILLIAM AURAND, THOMAS NELSON BLUMER, JOHN LINCOLN ETHELLS, MAURICE W. HOOVER, IVAN DUNLAVY JONES, MARVIN LUTHER SPECK

Associate Professors: THOMAS ALEXANDER BELL, DANIEL FROMM, FREDERICK GAIL WARREN

The Department of Food Science was established at State College in 1961 to integrate the various scientific disciplines which are basic to the preparation, processing, packaging, and distribution of foods in general. Programs of graduate study are offered leading to the Master of Science and Doctor of Philosophy degrees. In order to pursue graduate study in the field of food science, the student must possess adequate information in the fundamentals of the area in which he expects to specialize. The student's undergraduate education should have prepared him in mathematics, chemistry, biological and physical sciences as well as in the humanities and language skills. Following this preparation, the student can pursue more specialized fields.

In the area of food chemistry the student can conduct research and study in peroxidation of lipids in foods, flavor chemistry, protein denaturation, and various problems of biophysical chemistry.

Engineering aspects of food science are offered in the principles of automation and industrial engineering in food plant operations.

The field of food products technology is concerned with the development of new foods and the improved quality of existing foods.

Food microbiology is designed to offer study and research in fundamental principles of microbiology involved in promoting growth of microorganisms essential to the manufacture of various foods and the control of unwanted microorganisms in foods.

The department's physical facilities include research laboratories equipped for chemistry and microbiology, and processing facilities and equipment for dairy products, fruits and vegetables, and meats.

The Department of Food Science maintains close liaison with the faculties of supporting departments. Depending on the area chosen by the student for his major interest, he will have strong support for his minor from faculties in chemistry, economics, engineering, genetics, microbiology, and statistic.

Courses for Advanced Undergraduates

FS 401. Market Milk and Related Products **3-0**
Principles of processing, distribution and quality of fluid milk and related products. Mr. Warren.

FS 403. Ice Cream and Related Frozen Dairy Foods **0-3**
Prerequisite: FS 401

Choice, preparation and processing of ingredients and freezing of ice cream and other frozen desserts. Mr. Warren.

FS 404. (PO 404) Poultry Products **3-0**
Prerequisites: CH 101, ZO 103

Selection, processing, grading and packaging poultry meat and eggs. Factors involved in preservation of poultry meat and eggs. Mr. Fromm.

FS 410. Food Products Evaluation **0-3**
Prerequisites: ST 361 or equivalent

A comprehensive study of problems encountered in new food product development and consumer acceptance. A study of the nature of sensory responses with emphasis on taste, smell and appearance (color) as related to foods; design and methodology of small and large consumer panel testing; and the application of appropriate mathematical procedures to food acceptance testing and methodology. Mr. Hoover.

Courses for Graduates and Advanced Undergraduates

FS 502. Food Chemistry **3-0**
Prerequisite: CH 220 or 221

The basic composition, structure and properties of food, and the chemistry of changes occurring during processing and utilization of food. Interpretation and integration of widely published data in the food field with basic principles of chemistry. Mr. Aurand.

FS 503. Food Analysis **0-3**
Prerequisites: CH 215, CH 351, FS 502

A study of the principles, methods and techniques necessary for quantitative physical and chemical analyses of food and food products. Results of analysis will be studied and evaluated in terms of quality standards and governing regulations. Mr. Aurand.

FS 505. (BO 505) Food Microbiology **0-3**
Prerequisite: BO 412

The relationship of habitat to the occurrence of microorganisms on foods; environmental factors affecting the growth of various microorganisms in foods; microbiological action in relation to food spoilage and food manufacture; physical, chemical and biological destruction of microorganisms in foods; methods for microbiological examination of food-stuffs; and public health and sanitation bacteriology. Mr. Speck.

FS 506. (BO 506) Advanced Food Microbiology **3-0**
Prerequisite: FS 505 or consent of instructor

Ecology and physiology of microorganisms important in the manufacture

and deterioration of various classes of foods; the identification of representative species of such microorganisms isolated from natural environments; principles of nutrition, symbiosis and bacteriophage activity in culture maintenance for food production.

Mr. Speck.

FS 511. Food Science Seminar

0-1

Prerequisite: Senior or graduate standing and consent of instructor

A review and discussion of scientific articles, progress reports in research and special problems of interest.

Graduate Staff.

FS 512. Special Problems in Food Science

1-3 (arranged) f s

Prerequisite: Senior or graduate standing and consent of instructor

Analysis of scientific, engineering and economic problems of current interest in foods. The scientific appraisal and solution of a selected problem. The problems are designed to provide training and experience in research.

Graduate Staff.

FS 521, 522. Technology of Fruit and Vegetable Products

3-3

Prerequisite: BO 412

Comprehensive treatment of principles and methods of preservation of fruits and vegetables, including studies of commercial plant operations, and visits to food processing plants.

Mr. Hoover.

Courses for Graduates Only

FS 601. Seminar in Food Science

1-1

Preparation and presentation of scientific papers, progress reports of research and special topics of interest in foods.

Graduate Staff.

FS 602. Special Research Problems in Food Science

Credits by arrangement

Directed research in a specialized phase of food science designed to provide experience in research methodology and philosophy.

Graduate Staff.

FS 603. Research in Food Science

Credits by arrangement

Original research preparatory to the thesis for the Master of Science or Doctor of Philosophy degree.

Graduate Staff.

SCHOOL OF FORESTRY

Graduate Faculty

Professors: RICHARD JOSEPH PRESTON, *Dean*, ROY MERWIN CARTER, ERIC L. ELLWOOD, ARTHUR KELMAN, JOE O. LAMMI, T. EWALD MAKI, ALFRED J. STAMM, BRUCE J. ZOBEL

Associate Professors: CLARENCE ARTHUR HART, WILLIAM DYKSTRA MILLER, THOMAS O. PERRY

Assistant Professors: AIDOS C. BAREFOOT, MAURICE H. FARRIER

The School of Forestry offers graduate work leading to the master's and the Doctor of Philosophy degrees. Two types of master's programs are available to the graduate student.

The professional degrees of Master of Forestry and Master of Wood Technology are offered for students who are interested in advanced applications of fundamental principles to the specialized fields of forestry. The course program emphasizes professional specialization. There is no language requirement.

The degree of Master of Science is offered for the student who contemplates a career in research, in teaching, or both. The course of study for

the Master of Science degree provides for a comprehensive knowledge of forest management or wood technology and furnishes the training essential for successful research in these fields. Training is broadly-based and emphasizes fundamental science. There is both a thesis and language requirement.

The Doctor of Philosophy degree is available to forestry students of high intellectual capacity who can demonstrate the ability to undertake original research and scholarly work as the highest levels.

Candidates for the master's degree fall under one of the following categories:

1. Students with a bachelor's degree in forestry from a school of recognized standing. These students may secure the master's degree in one academic year.

2. Students with a bachelor's degree, other than in forestry, from a college, university, or scientific school of high standing. These students may secure the master's degree in two academic years provided they have the requirements in botany, chemistry, and mathematics required in the freshman and sophomore years of the curricula. Candidates for the degree of Master of Forestry or Master of Science in forest management who do not hold an undergraduate degree in forestry must start their program with the summer camp.

3. Students not possessing a bachelor's degree may earn, through proper selection of courses, a Bachelor of Science degree in one of the forestry curricula at the end of the fourth year and a master's degree in forestry or wood technology at the end of the fifth year.

A wide and rapidly expanding field of employment possibilities is available in the Southeast to young men trained in forestry. Until recent years most job opportunities were with government agencies in managing public forests. This field still constitutes a major source of employment. These agencies include state and federal forest services, extension services, and other groups such as the Soil Conservation Service and the Tennessee Valley Authority.

In recent years job opportunities with private industries have expanded greatly. Increasing numbers of technically trained young men are entering a wide variety of professional positions in the fields of forest land management, watershed management, logging, sawmilling, veneer and plywood manufacturing, pulp and papermaking, kiln drying, wood preservation, plastics and other chemical derivatives of wood, and the manufacture of wood products such as furniture, dimension stock, and various prefabricated items.

Graduate training offers tangible well-established values to young men of proven ability. The demand for men with advanced degrees in forestry has far exceeded the supply for many years.

Graduate preparation is essential for the specialists which are needed in many fields. Training through the master's degree is almost a requirement for men entering college teaching and public or industrial research. State and federal agencies as well as forest industries are employing research investigators at unprecedented levels.

The continuing rapid expansion of southern forestry has resulted in a corresponding expansion in the need for trained men. As a general rule most

employers will prefer a candidate with graduate training. While forest industry and public forest administration does not normally require graduate training, increasing numbers of positions in these fields are being filled by men with advanced forestry degrees, particularly the master's degree.

The administrative offices of the School of Forestry are located in Kilgore Hall. The first floor houses portions of the Wood Products Laboratory and the second and third floors consist of laboratories, library, classrooms, and offices. The Reuben B. Robertson Pulp and Paper Laboratory provides 12,000 square feet of space for teaching and research in the production of pulp and paper. The Brandon P. Hodges Wood Products Laboratory provides 18,000 square feet of space for pilot plant installations for product development work in the manufacture of lumber, veneer, plywood, particle board, laminated structures, furniture, and other fabricated wood products.

The School of Forestry now owns, or has access to, over 80,000 acres of forest land located in six tracts and representing major forest types in the State. The largest tract is the Hofmann Forest on the coastal plain which is operated by the North Carolina Forestry Foundation for the benefit of the School of Forestry. The Hill Forest in Durham County, the Hope Valley Forest in Chatham County, the Goodwin Forest in Moore County, and the Schenck Memorial Forest in Wake County include representative types of the Piedmont area. The Wayah Recreational Area of the North Carolina National Forest near Franklin is located in a typical mountain forest, and facilities at this area, leased from the Government, supplement the previously established forestry camps of the Hofmann and Hill Forests and provide the School with permanent, well-equipped, modern camps in each of the three major regions of the State.

An extensive research program in the fields of wood products, genetics and management, sponsored by the Agricultural Experiment Station, the U. S. Forest Service, and the lumber, plywood, furniture, pulp and paper, and particle board industries provides broad opportunities for graduate research at the master's and doctoral level. These programs offer research assistantships for graduate students whose backgrounds qualify them. Much valuable equipment is made available by industry for research in wood technology and it is accessible to the graduate student working in this area.

Courses for Advanced Undergraduates

FOR 403. Paper Process Analysis

0-3

Manufacture of several types of papers with particular attention to stock preparation, sizing, filling and coloring. The finished products are tested physically and chemically and evaluated from the standpoint of quality and in comparison with the commercial products they are intended to duplicate.

Mr. Hitchings.

FOR 404. Management Analysis

0-3

Application of management, logging, silvicultural and utilization practices on assigned areas. Each student must make a forest survey of an individual area and submit a record.

Messrs. Lammi, Miller.

FOR 405. Forest Inventory

0-3

Timber estimating and data compilation.

Messrs. Lammi, Miller.

FOR 411, 412. Pulp and Paper Unit Processes

3-3

Principles of operation, construction and design of process equipment in the pulp and paper industry.

Mr. Cook.

- FOR 413. Paper Properties and Additives** 4-0
Physical, chemical and microscopical examination of experimental and commercial papers and evaluation of the results in terms of the utility of the product tested. Messrs. Cook, Landes.
- FOR 422. Forest Products** 3-0
Prerequisites: FOR 201, CH 203 or 426
The source and method of obtaining derived and manufactured forest products other than lumber. Mr. Carter.
- FOR 423. Logging and Milling** 3-0
Timber harvesting and transportation methods, equipment and costs: safety and supervision; manufacturing methods with; log and lumber grades. Mr. Barefoot.
- FOR 432. Merchandising Forest Products** 2-0
Principles and practices in the distribution and marketing of the products obtained from wood; organization and operation of retail, concentration and wholesale outlets. Mr. Carter.
- FOR 434. Wood Operations I** 3-0
Prerequisites: FOR 301, 302
Organization of manufacturing plans producing wood products including company organization, plant layout, production planning and control. Analysis of typical manufacturing operations in terms of process, equipment, size and product specification. The organization and operation of Wood Products markets. Mr. Barefoot.
- FOR 435. Wood Operations II** 0-3
Prerequisites: FOR 301, 302
The application of the techniques of operations analysis to management decision making in the wood products field. Choice of products to manufacture. Allocation of production resources. Development of product distribution systems. Mr. Barefoot.
- FOR 441. Design of Wood Structures** 0-3
Prerequisite: EM 341
Strength and related properties of commercial woods; standard A.S.T.M. strength tests; toughness; timber fastenings; design of columns; simple, laminated and box beams; trusses and arches. Mr. Thomas.
- FOR 444. Introduction to Quality Control** 0-3
Prerequisite: ST 361
A study of methods used to control quality of manufactured wood products. Control charts for variable and attributes. Acceptance sampling techniques. Mr. Barefoot.
- FOR 461. Paper Converting** 0-1
A survey of the principal processes by which paper and paper board are fabricated into the utilitarian products of everyday use. Mr. Landes.
- FOR 462. Artificial Forestation** 0-2
Production collection, extraction, and storage of forest tree seeds; nursery practice; field methods of planting. Mr. Maki.
- FOR 463. Plant Inspections** 0-1
One week inspection trips covering representative manufactures of pulp paper and papermaking equipment. Staff.
- FOR 471. Pulping Process Analysis** 4-0
Preparation and evaluation of the several types of wood pulp. The influence of the various pulping and bleaching variables on pulp quality and studied experimentally and these data evaluated critically. Mr. Hitchings.
- FOR 481. Pulping Processes and Products** 0-2
Prerequisites: FOR 202, CH 203 or 221
Fiber manufacturing process and equipment; wall, insulation and contain-

er board products; manufacture of roofing felts; pulp products manufacturing; resin and specialty products, lignin and wood sugar products.

Mr. Landes.

FOR 482. Pulp and Paper Mill Management **0-2**

A survey of the economics of the pulp and paper industry is followed by a study of the work of the several departments of a paper mill organization and the functions of the executives who administer them.

Mr. Cook.

FOR 491, 492. Senior Problems

Problems selected with faculty approval in the areas of management or technology.

Credits arranged

Staff.

Courses for Graduates and Advanced Undergraduates

FOR 501. Forest Valuation

3-0

Prerequisite: FOR 372

The theory and techniques of valuation of forest land, timber stands, and forest practices as investments and for appraisals of damage. Risks and hazards in forestry as they apply to forest investments, forest insurance, and forest taxation.

Mr. Bryant.

FOR 511. Silviculture

0-3

Prerequisites: FOR 361, BO 421

The principle and application of intermediate and reproductive methods of cutting; controlled burning, silvicides, and other methods of hardwood control. The application of silvicultural methods in the forests of the United States.

Mr. Miller.

FOR 512. Forest Economics

3-0

Prerequisites: FOR 372, EC 201

Economics and social value of forests; supply of, and demands for forest products; land use; forestry as a private and a public enterprise; economics of the forest industries.

Mr. Lammi.

FOR 513. Tropical Woods

0-2

Prerequisites: FOR 203, 301

Structure, identification, properties, characteristics and use of tropical woods, especially those used in plywood and furniture.

Mr. Barefoot.

FOR 521, 522. Chemistry of Wood and Wood Products

3-3

Prerequisites: FOR 202, CH 215, 426, PY 212

Fundamental chemistry and physics of wood and wood components; pulp-impregnation principles; electrical and thermal properties.

Mr. Stamm.

FOR 531, 532. Forest Management

3-3

Prerequisite: FOR 372. Corequisite: FOR 511

Management of timber lands for economic returns; the normal forest taken as the ideal; the application of regulation methods to the forest.

Mr. Bryant.

FOR 533. Advanced Wood Structure and Identification

2-0

Prerequisite: FOR 202

Advanced microscopic identification of the commercial woods of the United States and some tropical woods; microscopic anatomical features and laboratory techniques.

Mr. Barefoot.

FOR 553. Forest Photogrammetry

0-2

Prerequisites: FOR 372, 531

Interpretation of aerial photographs, determination of density of timber stands and area mapping.

Mr. Bryant.

FOR 571. Advanced Forest Mensuration

3-0

Prerequisites: ST 311, FOR 372

Study of cyclical variation in growth of individual trees and stands; analysis of stand structures in even-aged versus all-age stands; general concepts of

growing stock levels on yields; evaluation of growth prediction methods.

Mr. Maki.

FOR 572. Forest Policy

3-0

Prerequisites: EC 201, FOR 219. Corequisite: FOR 531

Analysis of the forest policies of the United States and selected foreign countries; criteria for their evaluation; appraisal of current policies and alternatives.

Mr. Lammi.

FOR 573. Methods of Research in Forestry

Credits Arranged

Prerequisite: Senior or Graduate Standing

Research procedures, problem outlines, presentation of results; consideration of selected studies by forest research organizations; sample plot technique.

Messrs. Maki, Ellwood, Zobel.

FOR 591. Forestry Problems

Credits Arranged

Prerequisite: Senior or Graduate Standing

Assigned or selected problems in the field of silviculture, logging, lumber manufacturing, pulp technology, or forest management.

Staff.

Courses for Graduates Only

FOR 601. Advanced Forest Management Problems

Credits Arranged

Prerequisite: Graduate Standing

Directed studies in forest management.

Graduate Staff.

FOR 603. Technology of Wood Adhesives

3 or 3

Prerequisites: CH 425, 426; FOR 433

The fundamentals of adhesives as applied to wood-to-wood and wood-to-metal bonding. Technology of adhesives. Preparation and use of organic adhesives. Testing of adhesives and evaluation of quality of adhesives and bonded joints.

Mr. Hart.

FOR 604. Timber Physics

3 or 3

Prerequisite: FOR 441

Density, specific gravity and moisture content variation affecting physical properties; physics of drying at high and low temperatures; thermal, sound, light and electrical properties of wood.

Messrs. Ellwood, Hart.

FOR 605. Design and Control of Wood Processes.

3 or 3

Prerequisite: FOR 604

Design and operational control of equipment for processing wood.

Mr. Ellwood.

FOR 606. Wood Process Analysis

3-0

Prerequisites: FOR 512, 604

Analysis of wood process through the solution of comprehensive problems involving the physics of temperature and moisture relations.

Mr. Ellwood.

FOR 607. Advanced Quality Control

0-3

Prerequisites: FOR 606, ST 515

Advanced statistical quality control as applied to wood processing.

Mr. Hart.

FOR 611. Forest Genetics

3 or 3

Prerequisites: GN 411 and permission of instructor

Application of genetic principles to silviculture, management and pulp utilization. Emphasis is on variations in wild populations, on the bases for selection and desirable qualities and on fundamentals of controlled breeding.

Mr. Zobel.

FOR 621. Advanced Wood Technology Problems.

Credits Arranged

Prerequisite: Graduate Standing

Selected problems in the field of wood technology.

Graduate Staff.

FOR 671. Problems in Research**Credits Arranged**

Prerequisite: Graduate Standing

Specific forestry problems that will furnish material for a thesis.

Graduate Staff.

FOR 681. Graduate Seminar**1-1**

Prerequisite: Graduate standing in Forestry or closely allied fields

Presentation and discussion of progress reports on research, special problems and outstanding publications in forestry and related fields.

Graduate Staff.

DEPARTMENT OF GENETICS**Graduate Faculty**

Professors: HAROLD FRANK ROBINSON, *Head*, CAREY HOYT BOSTIAN, DANIEL SWARTWOOD GROSCH, WARREN DURWARD HANSON, BENJAMIN WARFIELD SMITH, STANLEY GEORGE STEPHENS

Associate Professors: KEN-ICHI KOJIMA, DALE FREDERICK MATZINGER

Assistant Professors: THERESE MARIE KELLEHER, LAWRENCE EUGENE METTLER, ROBERT HARRY MOLL, A. C. TRIANTAPHYLLOU

Associate Members of the Genetics Faculty

Professors: FRED DERWARD COCHRAN, COLUMBUS CLARK COCKERHAM, DAN ULRICH GERSTEL, EDWARD WALKER GLAZENER, WALTON CARLYLE GREGORY, PAUL HENRY HARVEY, FRANK LLOYD HAYNES, JR., TEDDY THEODORE HERBERT, GUY LANGSTON JONES, KENNETH RAYMOND KELLER, JAMES EDWARD LEGATES, THURSTON JEFFERSON MANN, GORDON KENNEDY MIDDLETON, PHILIP ARTHUR MILLER, ELMER LEON MOORE, HAMILTON ARLO STEWART, NASH NICKS WINSTEAD, BRUCE JOHN ZOBEL

Associate Professors: JAY LAWRENCE APPLE, ERNEST OSCAR BEAL, WILLIAM LOWERY BLOW, CHARLES ALOYSIUS BRIM, EMMETT URCEY DILLARD, JAMES WALKER HARDIN, RICHARD ROBERT NELSON, THOMAS O. PERRY, LYLE LLEWELLYN PHILLIPS, DANIEL TOWNSEND POPE, DONALD LORAIN THOMPSON, DAVID H. TIMOTHY

Assistant Professors: WILL ALLEN COPE, JOHN WESLEY DUDLEY, DONALD ALLEN EMERY, GENE JOHN GALLETTA, JOSHUA A. LEE, JOHN O. RAWLINGS, ODIS WAYNE ROBISON

Graduate study under direction of the genetics faculty may enable the student to qualify for the Master of Science or the Doctor of Philosophy degree. A candidate for the master's degree must acquire a thorough understanding of genetics and its relation to other biological disciplines and must present a thesis based upon his own research. In addition to a comprehensive knowledge of his field, a candidate for the doctorate must demonstrate his capacity for independent investigation and scholarship in genetics.

At North Carolina State College there are no sharp divisions along departmental lines between theoretical and applied aspects of genetic research. The members and associate members of the genetics faculty are located in nine different departments of the School of Agriculture, the School of Forestry, and the School of Physical Sciences and Applied Mathematics.

They are studying an extremely wide range of genetic problems and are utilizing not only the "classic" laboratory material (*Drosophila*, *Habrobracon*, mice) but also farm animals and agricultural and horticultural plants of the region. A student has, therefore, a wide choice of research problems in any of the following fields: cytology and cytogenetics, physiological and irradiation genetics, forest genetics, population genetics, and the application of quantitative genetics to breeding methodology. Arrangements with the University of North Carolina, School of Medicine enable specialized study in human and medical genetics.

The offices and laboratories of the department are located in Gardner Hall with greenhouse facilities adjacent to the building. A genetics garden for use in the intensive research with plants and teaching functions is located three miles from the departmental offices. The departmental staff and the associate faculty members in animal science, botany, crop science, horticultural science, poultry science, plant pathology, experimental statistics, and forest management are most fortunate in being able to draw upon the extensive facilities of the North Carolina Agricultural Experiment Station.

Courses for Advanced Undergraduates

GN 411. The Principles of Genetics

3 or 3

Prerequisites: BO or ZO 103

An introductory course. The physical basis of inheritance; genes as units of heredity and development; qualitative and quantitative aspects of genetic variation.

Mr. Bostian.

Courses for Graduates and Advanced Undergraduates

GN 503. (See ANS 503. Genetic Improvement of Livestock.)

GN 512. Genetics

4-0

Prerequisite: GN 411

Intended for students desiring more thorough and detailed training in fundamental genetics with some attention to physiological aspects. (Students conduct individual laboratory problems.)

Mr. Grosch.

GN 513. Cytogenetics I

4-0

Prerequisite: GN 512 or with consent of instructor

The chromosomes as vehicles of heredity. Mitosis and meiosis as bases of genetic stability and recombination. Structural and numerical aberrations and their effect upon the breeding systems of plants and animals. Inter-specific hybrids and polyploids. Lectures and laboratory.

Mr. Gerstel.

GN 520. (See PO 520. Poultry Breeding.)

GN 532. Biological Effects of Radiations

0-3

Prerequisite: ZO 103 (or with consent of instructor)

Qualitative and quantitative effects of radiations (other than the visible spectrum) on biological systems, to include both morphological and physiological aspects in a consideration of genetics, cytology, histology, and morphogenesis.

Mr. Grosch.

***GN 540. Evolution**

3-0

Prerequisite: GN 411

The facts and theories of evolution in plants and animals. The causes and consequences of organic diversity.

Mr. Smith.

* Offered in 1962-63 and alternate years.

- GN 541, CS 541 and HS 541. Plant Breeding Methods** 3-0
 Prerequisites: GN 512 and either ST 511 or consent of instructor
 Principles and methods of plant breeding. Graduate Staff.
- GN 542. (See CS 542 or HS 542. Plant Breeding Field Procedures.)**
- **GN 550. Experimental Evolution** 0-3
 Prerequisites: GN 512 and either GN 513 or consent of instructor
 Experimental evolution deals primarily with micro-evolutionary processes examined at the inter- and intra-specific population level. A review of the results from experimental population studies and analyses of natural populations concerning variation patterns and adaptation, natural selection, polymorphism, introgression, population breeding structure, isolating mechanism, etc., is made and interpreted in relation to Neo-Darwinian concepts of the origin of species. Mr. Mettler.

Courses for Graduates Only

- GN 602. (See ANS 602. Population Genetics in Animal Improvement.)**
- *GN 607 and PP 607. Genetics of Fungi** 3-0
 Prerequisite: GN 512 or equivalent and consent of instructor.
 Review of major contributions in fungus genetics with emphasis on principles and theories that have evolved in recent developments. Mr. Nelson.
- GN 611. (See FOR 611. Forest Genetics.)**
- **GN 614. Cytogenetics II** 0-3
 Prerequisites: GN 513 or consent of instructor
 Laboratory and discussion: the cytogenetic analysis of natural and experimental material, plant and animal. Assigned exercises and student projects. The course provides the student with a working knowledge of cytogenetic procedure. Mr. Smith.
- GN 626. (See ST 626. Statistical Concepts in Genetics.)**
- **GN 631. Mathematical Genetics** 3-0
 Prerequisites: GN 512 and ST 511 or consent of instructor
 History of mathematical biology, role of mathematical concepts in the development of genetic science, theory of genetic recombination, dynamics of genetic population. Mr. Kojima.
- GN 633. Physiological Genetics** 0-3
 Prerequisite: GN 512
 Recent advances in physiological genetics. Attention will be directed to literature on the nature and action of genes, and to the interaction of heredity and environment in the expression of the characteristics of organisms. Mr. Grosch.
- GN 641. Colloquium in Genetics** 2-2
 Prerequisites: Graduate standing, consent of instructor
 Informal group discussion of prepared topics assigned by instructor. Graduate Staff.
- GN 651. Seminar** 1-1
 Prerequisite: Graduate standing
- GN 661. Research** Credits by Arrangement
 Original research related to the student's thesis problem.
 A maximum of six credits for the Master's degree; by arrangement for the Doctorate. Graduate Staff.
- GN 671. Special Problems in Genetics** 1 to 3—1 to 3
 Prerequisites: Advanced graduate standing and consent of instructor
 Special topics designed for additional experience and research training. Graduate Staff.

* Offered in 1962-63 and alternate years.

** Offered in 1963-64 and alternate years.

GEOLOGICAL ENGINEERING

See Department of Mineral Industries

DEPARTMENT OF HISTORY AND POLITICAL SCIENCE**Graduate Faculty**

Professors: PRESTON WILLIAM EDSALL, *Head*, MARVIN L. BROWN, JR., FRED VIRGIL CAHILL, JR., JOHN TYLER CALDWELL, STUART NOBLIN

Associate Professors: BURTON FLOYD BEERS, WILLIAM JOSEPH BLOCK, ABRAHAM HOLTZMAN

No graduate degrees are offered in history or political science at State College. Graduate programs leading to advanced degrees in this field are offered at the University of North Carolina at Chapel Hill. The courses listed below are eligible for graduate credit when they form a part of an approved graduate program in other departments, and work in history and political science may serve as a minor field.

Courses for Advanced Undergraduates**HI 401. Russian History 3-0**

This course presents the major trends in Russian social, political, economic, and cultural history, with emphasis on the nineteenth and twentieth centuries. USSR policy is studied in relation to the full sweep of Russian history.

HI 402. Asia and the West 0-3

A history of Asia from the mid-nineteenth century to the present with emphasis on Asian nationalism and conflict with the imperial powers.

HI 409. Colonial America 2-0

A study of the development of the American colonies in the seventeenth and eighteenth centuries, with special emphasis on European backgrounds.

HI 412. Recent United States History 3 or 3

A study of the main current in American political, economic, social, and diplomatic history of the twentieth century.

HI 422. History of Science 3-0

A study of the evolution of science from antiquity to the present with particular attention given to the impact of scientific thought upon selected aspects of western civilization. The course provides a broad perspective of scientific progress and shows the interrelationship of science and major historical developments.

HI 433. American Agricultural History 3-0

Historical developments of agricultural activity in the United States from the transfer of western European agriculture to America to the present, with particular emphasis on the historical place and importance of agriculture in American life.

PS 401. American Parties and Pressure Groups 3 or 3

After a brief survey of those features of American government essential to an understanding of the political process, the course proceeds to examine the American electorate and public opinion and devotes its major attention to the nature, organization, and programs of pressure groups and political parties and to their efforts to direct opinion, gain control of government, and shape public policy. Special attention is given to party organization and pressure group activity at the governmental level and to recent proposals to improve the political party as an instrument of responsible government.

PS 406. Problems in North Carolina Government 0-2

Prerequisite: PS 201 or an acceptable substitute.

Selected problems arising from the operation of the legislative, administrative, and judicial machinery in North Carolina. In addition to acquiring a comprehensive view of these problems each student will make an intensive study of a special phase of one of them.

PS 431. International Organization 3-0

Prerequisite: PS 201 or HI 205 or an acceptable substitute

A study of the evolving machinery and techniques of international organization in the present century with particular emphasis on recent developments. The actual operation of international organization will be illustrated by the study of selected current international problems.

PS 452. The Legislative Process 0-3

A study of the formulation of public policy from the institutional and behavioral viewpoints. Important current legislative problems at the congressional and state legislative levels will be selected and will serve as a basis for analyzing the legislative process.

HI, PS 461. The Soviet Union 0-3

An analysis of the structure and function of the major Soviet economic, political, and social institutions with special stress on the historical roots and continuity of Russian civilization. The course is presented in three equal phases of approximately five weeks each, covering Russian history, Soviet government, and Soviet economy.

Courses for Graduates and Advanced Undergraduates

PS 501. Modern Political Theory 3-0

Prerequisite: PS 201 or HI 205 or an acceptable substitute

A study of the state and its relationship to individuals and groups, approached through the reading of selected passages from the works of outstanding political philosophers from the sixteenth century to the present.

Mr. Holtzman.

PS 502. Public Administration 0-3

Prerequisite: PS 201 or PS 202 or an acceptable substitute

A study of the principles and problems of administration in a democracy, including such matters as organization, personnel, fiscal management, relationship to the legislative and judicial functions, control of administrative agencies and policies, and public relations.

Mr. Block.

PS 510. (EC 510) Public Finance 0-3

Prerequisite: The basic course in Economics required by the degree-granting school.

A survey of the theories and practices of government taxing, spending, and borrowing, including inter-governmental relationships and administrative practices and problems.

Mr. Block.

PS 512. American Constitutional Theory 0-3

Prerequisite: PS 201 or an acceptable substitute

Basic constitutional doctrines, including fundamental law, judicial review, individual rights and political privileges, and national and state power. Special attention is given to the application of these doctrines to the regulation of business, agriculture, and labor and to the rights safeguarded by the First, Fifth, and Fourteenth Amendments to the Constitution.

Mr. Cahill or Mr. Edsall.

HI 534. (Same as RS 534) Farmers' Movements 0-3

Prerequisite: 3 credits in American history, American government, sociology or a related social science.

A history of agricultural organizations and movements in the United States and Canada principally since 1865, emphasizing the Grange, the Farmers' Alliance, the Populist revolt, the Farmers' Union, the Farm Bureau, the Equity societies, the Nonpartisan League, cooperative marketing, government programs, and present problems. Mr. Noblin.

Courses for Graduates Only

PS 610. Applied Principles of Public Administration 2-4 by arrangement
Prerequisite: PS 502 or an acceptable substitute

An advanced course in administrative principles and methods. Students will perform individual or group research, under supervision, in specific administrative topics within the context of those public agencies which function in their respective fields of technology. Mr. Block.

PS 620. Problems in Political Science 2-4 by arrangement
Prerequisite: Advanced graduate standing

An independent advanced research course in selected problems of government and politics. The problems will be chosen in accordance with the needs and desires of the students registered for the course. Graduate Staff.

DEPARTMENT OF HORTICULTURAL SCIENCE

Graduate Faculty

Professors: FRED DERWARD COCHRAN, *Head*, MONROE EVANS GARDNER, FRANK LLOYD HAYNES, JR., JOHN MITCHELL JENKINS, JR.

Associate Professors: WALTER ELMER BALLINGER, LEATON JOHN KUSHMAN, CLARENCE LESLIE MCCOMBS, DANIEL TOWNSEND POPE

Assistant Professors: THOMAS FRANKLIN CANNON, GENE JOHN GALLETTA, CONRAD HENRY MILLER, ROBERT JOHNSON SCHRAMM, JR.

The Department of Horticultural Science offers the Master of Science degree and the professional degree, Master of Horticulture. Evidence of high scholastic achievement in the basic biological sciences is particularly desirable for students who expect to study for the Master of Science degree in horticulture.

The department has excellent greenhouses, laboratories, cold storages, and access to adequate field plots, for graduate training in crop production, plant propagation, nutrition and physiology, biochemistry, morphology, plant breeding, cytology, and post-harvest physiology. The greenhouse range covers over 30,000 square feet of space and has twenty-one sections, each containing individual temperature and light control equipment. Laboratory facilities include four analytical laboratories, two cytological and anatomical laboratories, one soil testing laboratory for greenhouse control, one radio-isotope laboratory, and one landscape and floral design laboratory. Post-harvest facilities include, additionally, fourteen controlled temperature storage rooms; and grading, washing and packaging equipment. These combined facilities provide a wide variety of opportunities in basic and technical research in the horticultural field. An extensive, and varied assortment of plant materials is available for use in graduate programs.

The wide variations in climate and soils in North Carolina, from the coast to the mountains, make possible the study of plant responses under

these varied conditions. Land and facilities for horticultural research are available on ten of the outlying stations located throughout the State.

The opportunities for employment after advanced training include teaching and research in state and privately endowed educational institutions; research and regulatory positions with the United States Department of Agriculture, both foreign and domestic; extension specialists and county agents; research, production and promotional work with food, chemical, and seed concerns; orchard, nursery and greenhouse supervisors; and inspectors and quality control technologists.

Courses for Advanced Undergraduates

HS 411. Nursery Management 3-0

Prerequisites: BO 103, SSC 200

The principles and practices involved in the production, management, and marketing of field-grown and container-grown nursery plants. Field trips will be taken. Mr. Cannon.

HS 421. Fruit Production 3-0

Prerequisites: BO 103, SSC 200

A study of identification, adaptation, and methods of production and marketing of the principal tree and small fruits. Modern practices as related to selection of sites, nutritional requirements, management practices, and marketing procedures will be discussed. Mr. Correll.

HS 432. Vegetable Production 0-3

Prerequisites: BO 103, SSC 200

A study of the origin, importance, distribution, botanical relationships, and principles of production and marketing of the major vegetable crops. Mr. Miller.

HS 441. Floriculture I 3-0

Prerequisites: BO 103, SSC 200

The scope and importance of the commercial flower industry; the basic principles and practices involved in the production and marketing of flowers grown in the greenhouse and in the field. Mr. Randall.

HS 442. Floriculture II 0-3

Prerequisites: BO 103, SSC 200

Principles and methods of production of commercial flower crops in the greenhouse and in the field, including fertilization, moisture, temperature, and light relationships, insect and disease control, and marketing of cut flowers and pot plants. Mr. Randall.

HS 471. Arboriculture 0-3

Prerequisites: BO 103, SSC 200

A study of the principles and practices in the care and maintenance of ornamental trees and shrubs, such as pruning, fertilization, control of insects and diseases, and tree surgery. Field trips will be taken. Mr. Cannon.

HS 481. Breeding of Horticultural Plants 3-0

Prerequisite: GN 411

The application of genetic and other biological sciences to the improvement of horticultural crops. Messrs. Galletta, Henderson.

Courses for Graduates and Advanced Undergraduates

HS 501. Research Principles Credits by Arrangement

Prerequisite: Permission of Instructor

Investigation of a problem in horticulture under the direction of the instructor. The students obtain practice in experimental techniques and pro-

cedures, critical review of literature and scientific writing. The problem may last one or two semesters. Credits will be determined by the nature of the problem, not to exceed a total of 4 hours. Graduate Staff.

HS 541. (GN 541 or CS 541) Plant Breeding Methods 3-0

Prerequisites: GN 512; Recommended: ST 511

An advanced study of methods of plant breeding as related to principles and concepts of inheritance. Messrs. Timothy, Haynes.

HS 542. (GN 542 or FC 542) Plant Breeding 2 in Summer Sessions
Field Procedures

Prerequisites: HS 541 or CS 541 or GN 541

Laboratory and field study of the application of various plant breeding techniques and methods used in the improvement of economic plants.

Staff.

HS 552. Growth of Horticultural Plants 0-3

Prerequisite: BO 421

A study of the effect of nutrient-elements, water, light temperature, and growth substances on horticultural plants. Mr. Schramm.

HS 562. Post-Harvest Physiology 0-3

Prerequisite: BO 421

A study of chemical and physiological changes that occur during handling, transportation, and storage which affect the quality of horticultural crops. Consideration will be given to pre- and post-harvest conditions which influence these changes. Messrs. McCombs, Ballinger.

HS 581. Senior Seminar 1-1

Prerequisite: Senior in Horticulture

Presentation of scientific articles, progress reports in research, and special problems in horticulture and related fields. Mr. Gardner.

Courses for Graduates Only

HS 621. Methods and Evaluation of Horticultural Research 3-0

Prerequisite: Graduate standing

Principles and methods of research in the field of horticulture and their application to the solution of current problems. Critical study and evaluation of scientific publications. Compilation, organization, and presentation of data. Mr. Cochran.

HS 641. Research Credits by arrangement

Prerequisite: Graduate standing in Horticulture, consent of Chairman of Adv. Comm.

Original research on specific problems in fruit, vegetable, and ornamental crops. Thesis prepared should be worthy of publication. A maximum of 6 credits is allowed toward the Master of Science degree; no limitation on credits in Doctorate program. Graduate Staff.

HS 651. Seminar 1-1

Prerequisite: Graduate standing

Presentation of scientific articles and special lectures. Students will be required to present one or more papers. Attendance of all graduate students is required. Graduate Staff.

DEPARTMENT OF INDUSTRIAL ARTS

(See School of Education)

DEPARTMENT OF INDUSTRIAL EDUCATION

(See School of Education)

DEPARTMENT OF INDUSTRIAL ENGINEERING**Graduate Faculty**

Professors: CLIFTON A. ANDERSON, *Head*, ROBERT GORDON CARSON, JR., ROBERT W. LLEWELLYN

Visiting Professor: RUDOLPH WILLARD

The Department of Industrial Engineering offers graduate study leading to the Master of Science degree. The courses in this department reflect the new emphasis in the so-called operations research approach to the field.

Industrial engineering is concerned with the technical details of organizing men, materials, machines, capital and other resources to improve the efficiency of manufacturing, processing, and distribution activities. The basic education in industrial engineering emphasizes the utilization of the engineering sciences and mathematical and statistical analyses in the solution of planning, operating and control problems.

Courses for Advanced Undergraduates**IE 401. Industrial Engineering Analysis****3-0**

Prerequisites: IE 304, MA 405, ST 362

An introductory course in some of the more recently developed operations research techniques; applications of dynamic programming, replacement theory, Markov processes, queueing theory, linear programming; graphical methods of solutions; information theory and servomechanisms in Industrial Engineering. A balance will be sought between theory and practical applications.

IE 402. Industrial Engineering Analysis**0-3**

Prerequisite: IE 401

Continuation of IE 401.

IE 408. Production Control**3-0**

Planning, scheduling and dispatching of production in manufacturing operations; conversion of sales requirements into production orders; construction of production budgets and their relation to labor, materials and machines; laboratory project involving the development and operation of the production control system of a typical plant.

IE 425. Sales and Distribution Methods**0-2**

An analysis of the distribution of industrial and consumer products; the effect of increased productivity on sales and distribution channels; development and marketing of new products; merchandising and packaging. Sales training and sales engineering programs.

IE 430. Job Evaluation and Wage Incentives**0-3**

Job analysis, classification and specification. Grading, ranking, factor comparison and point systems of job evaluation in determining equitable rates for job content. Wages surveys and merit rating. Utilization of time standards in design, installation and operation of financial incentive plans. Comparison of various wage and salary plans. Effect of wage payment methods on industrial relations practices.

IE 443. Quality Control**0-3**

Economic balance between cost of quality and value of quality, and techniques for accomplishing this balance. Organization for, specification and utilization of quality controls. Statistical theory and analyses as applied to sampling, control charts, tolerance determination, acceptance procedures and control of production.

Courses for Graduates and Advanced Undergraduates

IE 515. Process Engineering

3-0

Prerequisites: IE 401, 443

The technical process of translating product design into a manufacturing program. The application of industrial engineering in the layout, tooling, methods, standards, costs and control functions of manufacturing. Laboratory problems covering producer and consumer products.

Graduate Staff.

IE 517. Automatic Processes

3-0

Prerequisites: IE 401, 443

Principles and methods for automatic processing. The design of product, process, and controls. Economic, physical, and sociological effects of automation.

Graduate Staff.

IE 521. Control Systems and Data Processing

3-0

Prerequisite: IE 401

This course is designed to train the student in the problem and techniques required for systematic control of the production process and the business enterprise. This includes training in the determination of control factors, the collection and recording of data, and the processing, evaluation and use of data. The course will illustrate the applications and use of data processing equipment and information machines in industrial processes. Case problems will be used extensively.

Mr. Llewellyn.

IE 531. Quantitative Job Evaluation Methods

0-3

Prerequisite: IE 401

A study of statistical and mathematical methods of testing and designing job evaluation plans. Ranking, contingency, and analysis of variance methods of testing plans and rating performance. Multiple regression and linear programming methods of designing plans.

Mr. Llewellyn.

IE 543. Standard Data

3-0

Prerequisites: ST 361 or ST 515, one course in motion and time study.

Theory and practice in developing standard data from stopwatch observations and predetermined time data; methods of calculating standards from data; application of standard data in cost control, production planning and scheduling, and wage incentives.

Mr. Anderson.

IE 546. Advanced Quality Control

0-3

Prerequisites: IE 304 or ST 362

The statistical foundation of Quality Control are emphasized in this course as well as its economic implications. Mathematical derivation of most of the formulas used are given. Sampling techniques are treated extensively and many applications of this powerful technique are explained.

Graduate Staff.

IE 551. Standard Costs for Manufacturing

0-3

Prerequisites: One course in accounting and one course in motion and time study.

The development, application and use of standard costs as a management tool; use of industrial engineering techniques in establishing standard costs for labor, material and overhead. Analysis of variances and setting of budgets. Measures of management performance.

Mr. Willard.

IE 581. Project Work

2 to 6—2 to 6

Prerequisite: Graduate or senior standing

Investigation and report on an assigned problem for students enrolled in the fifth-year curriculum in Industrial Engineering.

Graduate Staff.

Courses for Graduates Only**IE 621. Inventory Control Methods****0-3**

Prerequisites: IE 402, IE 521, MA 511

A study of inventory policy with respect to reorder sizes, minimum points and production schedules. Simple inventory models, models with restrictions, price breaks, price changes, analysis of slow-moving inventories. Introduction to the smoothing problem in continuous manufacturing. Applications of linear and dynamic programming and zero-sum game theory.

Mr. Llewellyn.

IE 651. Special Studies in Industrial Engineering**Credits by Arrangement**

Prerequisite: Graduate standing

The purpose of this course is to allow individual students or small groups of students to take on studies of special areas in Industrial Engineering which fit into their particular program and which may not be covered by existing industrial engineering graduate level courses. The work would be directed by a qualified staff member who had particular interest in the area covered by the problem. Such problems may require individual research and initiative in the application of industrial engineering training to new areas or fields.

Graduate Staff.

IE 671. Seminar**1-1**

Seminar discussion of industrial engineering problems for graduate students. Case analyses and reports.

Mr. Anderson.

IE 691. Industrial Engineering Research**Credits by arrangement**

Graduate research in Industrial Engineering for thesis credit.

Graduate Staff.

DEPARTMENT OF MATHEMATICS**Graduate Faculty**

Professors: JOHN WESLEY CELL, *Head*, ROBERTS COZART BULLOCK, JOHN MONTGOMERY CLARKSON, WALTER JOEL HARRINGTON, JACK LEVINE, CAREY GARDNER MUMFORD, PETER MUSEN, HOWARD MOVES NAHIKIAN, HUBERT VERN PARK, RAIMOND ALDRICH STRUBLE, JAMES HATTON WAHAB, LOWELL SHERIDAN WINTON

Associate Professors: GEORGE CHARLES CALDWELL, CONSTANTINE KASSIMATIS, DARRELL RHEA SHREVE, HERBERT ELVIN SPEECE

Adjunct Associate Professor: ROBERT TAYLOR HERBST

Assistant Professors: JOHN WILLIAM BISHIR, ROBERT ROY KORFHAGE, MORTON LOWENGRUB

Visiting Assistant Professor: JACOB BURLAK

The Department of Mathematics offers graduate studies in applied mathematics leading to the Master of Science and Doctor of Philosophy degrees. A student entering this graduate program is expected to have had a strong undergraduate major in mathematics, including a year of advanced calculus and at least a semester of advanced modern algebra and a minor in some mathematically oriented area such as physics, the engineering sciences, or genetics. He is expected to choose a minor area of study other than mathematics.

Individuals with graduate training in applied mathematics are in great demand in industry, in governmental laboratories, and in college teaching

positions. Opportunities are many and varied in this field and include work as a member of a research team in such areas as satellite orbit theory, viscoelasticity, biomathematics, thermodynamics, aerodynamics, acoustics, solid state physics, nuclear reactor theory, geophysics, and in applications of computers in business.

The department has available a number of teaching and research assistantships (a student holding a half-time assistantship is allowed to carry a study load of nine semester hours). Also available for those graduate students studying toward the Ph.D. degree are a limited number of NDEA and Ford Foundation fellowships.

Courses for Advanced Undergraduates

- MA 401. Intermediate Differential Equations** **3-3**
 Prerequisite: MA 301
 Theory of linear independence of solutions of linear differential equations, variation of parameters, superposition integral, simultaneous linear differential equations by transform methods, series solutions, special functions (Bessel, Legendre, etc.), orthogonal functions, and partial differential equations by separation of variables.
- MA 403. Fundamental Concepts of Algebra** **3-0**
 Prerequisites: MA 202 or MA 212
 Integers; integral domains; rational numbers; fields, rings, groups. Boolean algebra.
- MA 404. Fundamental Concepts of Geometry** **0-3**
 Prerequisite: MA 202 or MA 212
 Foundations of geometry; laws of logic; affine geometry; geometric transformations; homogeneous coordinates; comparison of Euclidean and non-Euclidean geometries.
- MA 405. Introduction to Determinants and Matrices** **3-3**
 Prerequisite: MA 202 or MA 212
 Properties of determinants; theorems of Laplace and Jacobi; systems of linear equations. Elementary operations with matrices; inverse, rank, characteristic roots and eigenvectors. Introduction to algebraic forms.

Courses for Graduates and Advanced Undergraduates

- MA 511. Advanced Calculus I** **3-3**
 Prerequisite: MA 301 and, preferably, a B-average in mathematics courses
 Vectors, differential calculus of functions of several variables, vector differential calculus, integral calculus of functions of several variables.
Graduate Staff.
- MA 512. Advanced Calculus II** **3-3**
 Prerequisite: MA 511
 Vector integral calculus, infinite series. Graduate Staff.
- MA 513. Advanced Calculus III** **3-3**
 Prerequisite: MA 512
 Functions of a complex variable, Fourier series. Graduate Staff.
- MA 514. Methods of Applied Mathematics** **3-3**
 Prerequisite: MA 512
 Introduction to difference equations, integral equations, and calculus of variations. Graduate Staff.
- MA 516. Principles of Mathematical Analysis** **3-0**
 Prerequisite: MA 512
 The real number system, elements of set theory, limits, continuity, differen-

tion, Riemann-Stieltjes integration, sequences of functions, fundamentals of Lebesgue theory, axiomatic development of set theory, topological and metric spaces.

MA 517. Introduction to Point-Set Topology

0-3

Prerequisite: MA 516

A study of basic set-theoretic and general topological notions of modern mathematics. Topics include set theory and cardinal numbers, topological spaces, metric spaces, and elementary discussion of function spaces.

Graduate Staff.

MA 522. Theory of Probability I

3-3

Prerequisite: MA 511 or consent of instructor

Definitions, discrete and continuous sample spaces, combinatorial analysis, Stirling's formula, simple occupancy and ordering problems, conditional probability, repeated trials, compound experiments, Bayes' theorem, binomial, Poisson and normal distributions, the probability integral, random variables, expectation.

Graduate Staff.

MA 523. Theory of Probability II

0-3

Prerequisites: MA 405 and MA 522

Binominal, Poisson, and normal distributions, law of large numbers, recurrent events, renewal theory, Markov chains. Characteristic function and distribution functions, simple stochastic processes. Introduction to game theory and linear programming.

Graduate Staff.

MA 527. Numerical Analysis I

3-0

Prerequisite: MA 511

Numerical solution of equations, introduction to the theory of errors, finite-difference tables and the theory of interpolation, numerical integration, numerical differentiation, and elements of difference calculus.

Graduate Staff.

MA 528. Numerical Analysis II

0-3

Prerequisite: MA 527

Difference operators, summation procedures, numerical solution of ordinary differential equations, least-squares polynomial approximation, and Gaussian quadrature.

Graduate Staff.

MA 532. Differential Equations II

0-3

Prerequisite: MA 511

Phase-plane concepts; elementary critical points and stability theory; second order linear equations with variable coefficients; general linear autonomous systems; forced oscillations of linear systems; the method of Frobenius; Bessel, Legendre and hypergeometric functions; regular singular points; Sturm-Liouville systems; eigenvalue problems and generalized Fourier expansions; existence and uniqueness theorems.

Graduate Staff.

MA 536. Logic for Digital Computers

3-0

Prerequisite: MA 511

Introduction to logic and formal languages of digital computers, algorithms, compilers, and heuristic programming.

Graduate Staff.

MA 537. Non-numeric Uses of Computers

0-3

Prerequisite: MA 536

The use of computers in problems not involving numerical analysis. Formal differentiation and integration, algebraic models, combinatorics, theorem proving and decision making. Problems of mechanical translation. Special computers.

Graduate Staff.

MA 551. (PY 551) Principles of Astrodynamics

3 or 3

Prerequisites: MA 511, either PY 401 or EM 312

The differential equations of motion in two-body problems and their integrals; orbit theory; integrals of the n-body problem; differential equations

of motion of natural and artificial satellites and their approximate solutions.
Mr. Musen.

Courses for Graduates Only

MA 602. Partial Differential Equations

0-3

Prerequisite: MA 512

Ordinary differential equations in more than two variables, partial differential equations of the first order, partial differential equations of the second order, Laplace's equation, the wave equation, the diffusion equation.
Mr. Struble.

MA 605. Non-Linear Differential Equations

3-0

Prerequisites: MA 512, MA 532

Phase-plane and phase-space concepts; existence and uniqueness theorems; continuity, analytic and differentiability properties of solution; properties of linear systems; stability in non-linear systems; topological methods; perturbations of periodic solutions; asymptotic methods and resonance problems.
Mr. Struble.

*MA 608. Integral Equations

3

Prerequisites: MA 512, MA 532

Linear Volterra integral equations of the first and second kinds. Relationship to linear differential initial value problems. Special Volterra equations of the convolution type. Singular Volterra equations. Linear Fredholm integral equations of the first and second kind. Basic theory. Symmetric kernels. Hilbert-Schmidt theory (generalizations).
Mr. Winton.

MA 611. Complex Variable Theory and Applications I

3-0

Prerequisite: MA 512

Elementary functions; analytic functions and Cauchy-Riemann equations; conformal mapping and applications; Taylor and Laurent series; contour integration and residue theory; the Schwarz-Christoffel transformation.
Mr. Bullock.

MA 612. Complex Variable Theory and Applications II

0-3

Prerequisite: MA 611

Conformal mapping and applications to flow phenomena; multiple-valued functions and Riemann surfaces; further applications of residue theory; analytic continuation; infinite series and asymptotic expansions; elliptic functions and other special functions in the complex domain; structure of functions.
Mr. Bullock.

MA 615. Theory of Functions of a Real Variable I

3-0

Prerequisite: MA 512

Sets and spaces; continuity and differentiability of real functions.
Mr. Harrington.

MA 616. Theory of Functions of a Real Variable II

0-3

Prerequisite: MA 615

Measure, measurable sets and functions, theory of Lebesgue integration.
Mr. Harrington.

MA 621. Introduction to Modern Abstract Algebra

3-0

Prerequisite: MA 512

A study of the abstract structure and properties of groups, rings and ideals, and fields.
Messrs. Nahikian, Park, Wahab.

MA 622. Vector Spaces and Matrices

0-3

Prerequisite: MA 511

A study of vector spaces and their relation to the theory of matrices. Matrix inversion, linear transformations, including similarity and orthogonal trans-

* Offered in 1963 and alternate summers.

formations, canonical forms. Properties of the characteristic and reduced characteristic function. Elementary divisors and functions of matrices. Applications to systems of differential equations.

Messrs. Nahikian, Park, Wahab.

****MA 625. Introduction to Differential Geometry** **3**
Prerequisite: MA 512

Theory of curves and surfaces in 3-dimensional euclidean space with special reference to those properties invariant under the rigid body motions.

Messrs. Levine, Winton.

MA 632. Operational Mathematics I **3-0**
Corequisite: MA 513 or MA 611

Laplace transform with theory and application to problems in ordinary and partial differential equations arising from engineering and physics problems; Fourier integral and Fourier transforms and applications.

Mr. Cell.

MA 633. Operational Mathematics II **0-3**
Prerequisite: MA 632

Extended development of the Laplace and Fourier transforms and their uses in the solution of problems in ordinary and partial differential equations and in difference equations; Sturm-Liouville systems; advanced theory in ordinary and partial differential equations; other infinite and finite transforms and their applications.

Mr. Cell.

MA 635. Mathematics of Computers **0-3**
Prerequisites: MA 528, MA 512, MA 335; Corequisite: MA 405 or MA 622

The development of methods for the solution of selected problems involving matrices; integral rational equations; ordinary and partial differential equations. Particular attention is paid to the question of convergence and stability; examples solved on the IBM 650.

Graduate Staff.

***MA 641. Calculus of Variations** **3**
Prerequisite: MA 512

The simplest problem of the calculus of variations in detail; variable end-points; iso-perimetric problems; Hamilton's principle; least action principle; introduction to the theory of linear integral equations of the Volterra and Fredholm types.

Mr. Winton.

****MA 651. Expansion of Functions** **3**
Prerequisites: MA 611, 633 or equivalent

Expansion of functions of one or more variables in Taylor series; asymptotic series; infinite products, partial fractions, continued fractions, series of orthogonal functions; applications in ordinary partial differential equations, difference equations and integral equations.

Messrs. Cell, Harrington.

MA 655. Mathematics of Astrodynamics I **3-0**
Prerequisite: MA 532 or MA 605

Two-body problem and its integrals, differential equations of the disturbed planetary motion, disturbing function (potential of the disturbed motion), literal and numerical methods for expansion of the disturbing function, perturbation of the first and second order, methods of Hansen, Hill, and Brouwer, theory of resonance.

Mr. Musen.

MA 656. Mathematics of Astrodynamics II **0-3**
Prerequisite: MA 655

Theories of artificial satellites, influence of the sun and moon on the motion of artificial satellites, orbit stability, lunar theories.

Mr. Musen.

* Offered in 1963 and alternate summers.

** Offered in 1962 and alternate summers.

MA 661. Tensor Analysis I**3-0**

Prerequisite: MA 512

The basic theory, tensor algebra, tensor calculus; invariants of quadratic differential forms; covariant differentiation; geometric applications, Riemannian spaces; generalized vector analysis.

Mr. Levine.

MA 662. Tensor Analysis II**0-3**

Prerequisite: MA 661

Continuation of MA 661. Physical applications; dynamics, Lagrange's equations, the geometry of dynamics, configuration spaces. Further applications to electromagnetic theory and elasticity.

Mr. Levine.

MA 681. Special Topics in Analysis**up to 6 hours credit****MA 683. Special Topics in Algebra****up to 6 hours credit****MA 685. Special Topics in Numerical Analysis****up to 6 hours credit****MA 687. Special Topics in Geometry****up to 6 hours credit****MA 689. Special Topics in Applied Mathematics****up to 6 hours credit**

The above courses, MA 681-MA 689, afford opportunities for graduate students to study advanced topics in mathematics under the direction of members of the graduate staff. These will on occasion consist of one of several areas such as, for example, advanced theory of partial differential equations, topology, mathematics and plasticity or of viscoelasticity, mathematics or orbital mechanics.

Graduate Staff.

MA 691. Research in Mathematics**Credits by arrangement**

Prerequisite: Graduate standing and approval of adviser

Individual research in the field of mathematics.

Graduate Staff.

DEPARTMENT OF MECHANICAL ENGINEERING**Graduate Faculty**

Professors: ROBERT W. TRUITT, *Head*, NORVAL WHITE CONNER, JESSE SEYMOUR DOOLITTLE, *Graduate Administrator*, KARL P. HANSON, HASSAN AHMAD HASSAN, RICHARD BENNETT KNIGHT, ROBERT MCLEAN PINKERTON, JAMES WOODBURN

Associate Professors: M. R. EL-SADEN, FREDERICK O. SMETANA, JOHN KERR WHITFIELD, CARL FRANK ZOROWSKI

Assistant Professors: THOMAS BENSON LEDBETTER, RICHARD S. LEE, JAMES T. YEN

The Department of Mechanical Engineering offers graduate study leading to the Master of Science and Doctor of Philosophy degrees. Entrance to the various programs in the department is normally based upon an accredited baccalaureate degree in engineering.

At present, the major emphases in graduate study are the thermal sciences, including classical thermodynamics, heat transfer and transport phenomena, statistical thermodynamics; gas dynamics (aerothermochemistry, aerothermodynamics) and the mechanical sciences, such as principles of fluid motion, dynamics of compressible flow and viscous fluids, vibrations, mechanical transients, stress analysis, and applied mechanics; the aero and space science of aerodynamics, propulsion, and aeroelasticity.

The professional technological interests of the department are represented by graduate courses in nuclear power plants, steam and gas turbines, refrigeration, internal combustion engines, lubrication, mechanics of machinery, and machine design analysis and synthesis.

Graduate programs in mechanical engineering normally include substantial work in the basic sciences of mathematics and physics, and study in related engineering departments is encouraged.

The fundamental objective of graduate study in this field is to prepare the student for leadership in the various categories of research, teaching, and design. The graduate student is placed in close association with the graduate faculty who conduct individual research. Participation in a research project as a research assistant or employment as a teaching assistant is regarded as significant experience during residence.

Courses for Advanced Undergraduates

ME 401. Power Plants

3 or 3

Prerequisite: ME 302

Required of seniors in Mechanical Engineering

Application of thermodynamics, economics and other basic studies to the engineering of power generation, with emphasis on energy balances, combustion, steam generation, prime movers, heat transfer devices and auxiliaries.

ME 405. Mechanical Engineering Laboratory III

1-0

Prerequisite: ME 306

Required of seniors in Mechanical Engineering

The selection of appropriate instrumentation and the experimental analysis of small, predetermined engineering systems designed for flexibility and wide variation of parameters. Systems cover the gamut of Mechanical Engineering activity with emphasis on analysis of system rather than characteristics of particular systems.

ME 406. Mechanical Engineering Laboratory IV

0-1

Prerequisite: ME 405

Required of seniors in Mechanical Engineering

Individual or small group investigation of an original problem under the supervision of a faculty member with an interest in the problem area. The investigation may be experimental, analytical, or both. Emphasis is placed on the philosophy and methodology of engineering research, and on individual thinking and effort.

ME 410. Jet Propulsion

0-3

Prerequisites: ME 302 and ME 352 or EM 430

Application of fundamental principles of thermodynamics and the mechanics of a compressible fluid to the processes of jet-propulsion and turbo-propeller aircraft; the effect of performance of components on performance of engine; analysis of engine performance parameters.

ME 411. Machine Design I

3-0

Prerequisites: ME 312, EM 321

Required of seniors in Mechanical Engineering

Basic principles of the mechanical sciences applied to the analysis of machines, devices, and mechanical systems. State of stress, state of strain, elasticity, working stresses, stress concentration, fatigue, impact and shock, plasticity, thermal stress, wear, lubrication and contact stress.

ME 412. Machine Design II

0-3

Prerequisite: ME 411

Required of seniors in Mechanical Engineering

Synthesis of machines, devices, and mechanical systems. The specification of systems, formulation of region of design, synthesis of elements, complete analysis of the ensemble, evaluation and closure of the design. Project activity with research emphasis.

ME 421. Aerospace Propulsion Systems**0-3**

Prerequisites: ME 361, ME 302

A study of propulsion systems and their relation to the various flight regimes and space missions. The principles of thrust generation, the control, and the performance of various propulsion systems will be considered.

ME 435. Industrial Automatic Controls**3 or 3**

Prerequisites: ME 301, MA 301

Introduction to concept of automatic controls; fundamentals of two-position, proportional, floating and rate modes of control with a graphical and analytical presentation of each. Theoretical considerations of the process and an introduction to system analysis.

ME 441, 442. Technical Seminar**1-1**

Prerequisite: Junior or senior standing

Meetings once a week for the delivery and discussion of student papers on topics of current interest in Mechanical Engineering.

ME 466. Performance of Hypervelocity Vehicles**0-3**

Prerequisites: ME 361

The application of the aerospace sciences to the estimation of the performance, stability and control of hypervelocity vehicles.

ME 451. Introduction to Rocketry**3 or 3**

Prerequisites: ME 301 and 351, or equivalent

Basic principles of rocket propulsion. Consideration of the significance and use of parameters such as specific impulse, characteristic velocity, thrust coefficient. General description of liquid, solid and hybrid power plants. Performance calculations and design considerations.

ME 453. Applied Aerodynamics**3-0**

Prerequisite: ME 352

Determination of design data, tunnel wall and ground effect interference corrections, spanwise and chordwise load distributions, performance estimation, and stability and control analysis. Attention is given to transonic and supersonic aerodynamics.

ME 465, 466. Aerospace Engineering Laboratory**1-1**

Prerequisite: ME 361

Laboratory experience in wind tunnel experimentation, structural testing, environmental testing, and instrumentation for flight in and beyond the atmosphere.

ME 469. Spacecraft Structures**3-0**

Prerequisites: ME 361, EM 321

To provide the basic structural background necessary to the design of light weight structures for flight in and beyond the atmosphere.

ME 471. Aircraft and Missile Design**3-0**

Prerequisite: ME 361

Elements of the design of modern aircraft and highspeed missile configuration to meet prescribed aerodynamic, structural, performance, and stability specifications.

ME 472. Spacecraft Design**0-3**

Prerequisite: ME 361

A study of flight requirements leading to determination of flight criteria and the specifications of spacecraft systems. The application of aerospace sciences to the design of spacecraft.

Courses for Graduates and Advanced Undergraduates

ME 501. Steam and Gas Turbines**3 or 3**

Prerequisites: ME 302 and ME 352 or EM 430

Fundamental analysis of the theory and design of turbomachinery flow

passages; control and performance of turbomachinery; gas-turbine engine processes.

Mr. Doolittle.

ME 502. Heat Transfer

3 or 3

Prerequisite: ME 301, MA 301

A study of the fundamental laws of heat transfer by conduction, convection and radiation; steady and unsteady state heat transfer.

Mr. Doolittle.

ME 503, 504. Elements of Nuclear Power Generation, I, II

3-3

Prerequisite: CHE 521

Engineering analysis and calculations involved in the elements of nuclear power generation including ideal and actual power cycles, prime movers and appurtenances. Elements of the cost of power and the engineering economics of selection of equipment. The nuclear reactor development and status as a source of power including a critical review of recent developments.

Mr. Hanson.

ME 507, 508. Internal Combustion Engine Fundamentals

3-3

Prerequisite: ME 302

The fundamentals common to internal combustion engine cycles of operation. The Otto engine: carburetion, fuel distribution, flame propagation, normal and knocking combustion, throttling, pumping, valve and spark timing, and altitude effects; the Diesel engine: injection and spray formation, fuel rating, atomization, penetration, diesel knock, combustion, pre-combustion, and scavenging, as applied to reciprocating and rotary engines.

Mr. Ledbetter.

ME 515. Experimental Stress Analysis

3 or 3

Prerequisite: ME 312

Stresses determined experimentally by photoelasticity methods, by mechanical and electrical strain gages, by brittle coatings, etc. Effects of varying stresses.

Mr. Whitfield.

ME 516. Photoelasticity

0-3

Prerequisite: ME 515

Two and three-dimensional photoelasticity; the stress-optic law, isochromatics, isoclinics, stress trajectories, fractional orders of interference; three dimensional techniques, oblique incidence, rotational and thickness effects; determination of principal stresses at interior points; laboratory investigations.

Mr. Whitfield.

ME 517. Lubrication

0-3

Prerequisite: EM 430

The theory of hydrodynamic lubrication; Reynolds' equation, the Sommerfeld integration, effect of variable lubricant properties and energy equation for temperature rise. Properties of lubricants. Application to design of bearings. Boundary lubrication.

Mr. Woodburn.

ME 521. Aerothermodynamics

3 or 3

Prerequisites: ME 301, MA 301, EM 430

An examination of the basic concepts of gas dynamics such as the continuum, domain of applicability of continuum, acoustic velocity, compressibility effects, and the conservation laws. Analysis of one dimensional flows such as isentropic flow, diabatic flow, flow with friction, the normal shock. An introduction to the vector formulation of multi-dimensional problems.

Mr. Smetana.

ME 541, 542. Aerodynamic Heating

3-3

Prerequisites: MA 511, ME 521 or equivalent

A detailed study of the latest theoretical and experimental findings of the compressible laminar and turbulent boundary layers with special attention to the aerodynamic heating problem; application of theory in the analysis and design of aerospace hardware.

Mr. Truitt.

- ME 545, 546. Project Work in Mechanical Engineering I, II** **2-2**
 Individual or small group investigation of a problem stemming from a mutual student-faculty interest. Emphasis is placed on providing a situation for exploiting student curiosity. Graduate Staff.
- ME 554. Advanced Aerodynamic Theory** **0-3**
 Prerequisite: ME 453
 Development of fundamental aerodynamic theory. Emphasis upon mathematical analysis and derivation of equations of motion, airfoil theory and comparison with experimental results. Introduction to supersonic flow theory. Mr. Pinkerton.
- ME 562. Advanced Aircraft Structures** **0-3**
 Prerequisites: ME 459, ME 453
 Development of methods of stress analysis for aircraft structures, special problems in structural design, stiffened panels, rigid frames, indeterminate structures, general relaxation theory. Mr. Whitfield.
- ME 571. Air Conditioning** **3-0**
 Prerequisite: ME 302
 A fundamental study of summer and winter air conditioning including temperature, humidity, air velocity and distribution. Mr. Knight.
- ME 572. Refrigeration** **0-3**
 Prerequisite: ME 302
 A thermodynamic analysis of the simple, compound, centrifugal and multiple effect compression systems, the steam jet system and the absorption system of refrigeration. Mr. Knight.
- ME 581, 582. Hypersonic Aerodynamics** **3-3**
 Prerequisites: MA 512, ME 352 or equivalent
 A detailed study of the latest theoretical and experimental findings in hypersonic aerodynamics. Mr. Truitt.

Courses for Graduates Only

- ME 601. Advanced Engineering Thermodynamics** **3-0**
 Prerequisites: ME 302 or ME 303, and MA 301
 First and Second Laws; theory of variable specific heats; general equations of thermodynamics; characteristic equations of state; reduced coordinates; prediction of properties of gases and vapors; chemical equilibrium; metastable states; thermodynamics of fluid flow.
- ME 602. Statistical Thermodynamics** **0-3**
 Prerequisites: ME 601, ME 511
 Fundamental principles of kinetic theory, quantum mechanics, statistical mechanics and irreversible phenomena with particular reference to thermodynamics systems and processes. The conclusions of the classical thermodynamics are analyzed and established from the microscopic viewpoint. Mr. El-Saden.
- ME 603. Advanced Power Plants** **3-0**
 Prerequisite: ME 401
 A critical analysis of the energy balance of thermal power plants; thermodynamic and economic evaluation of alternate schemes of development; study of recent developments in the production of power. Mr. Hanson.
- ME 605. Aerothermochemistry** **0-3**
 Prerequisites: ME 601, MA 511 or equivalent
 A generalized treatment of combustion thermodynamics including derivation of thermodynamics quantities by the method of Jacobians, criteria for thermodynamic equilibrium, computation of equilibrium composition and adiabatic flame temperature. Introduction to classical chemical kinetics. Conservation equations for a reacting system, detonation and deflagration.

Theories of flame propagation, flame stabilization, and turbulent combustion.
Mr. Hassan.

ME 606. Advanced Gas Dynamics

0-3

Prerequisites: ME 521, ME 601, MA 511

The general conservation equations of gas dynamics from a differential and integral point of view. Hyperbolic compressible flow equations, unsteady one-dimensional flows, the non-linear problem of shock wave formation, isentropic plane flow, flow in nozzles and jets, turbulent flow.

Mr. Smetana.

ME 608. Advanced Heat Transfer I

3-0

Prerequisite: ME 502 or equivalent

Fundamental aspects, from an advanced viewpoint, will be considered in the conduction of heat through solids, convective phenomena, and the measurement and prediction of appropriate physical properties. Boundary value problems arising in heat conduction will be examined and both numerical and function solution techniques developed. Internal and external boundary layer analyses will be made on a variety of representative convection situations.

Mr. Lee.

ME 609. Advanced Heat Transfer II

0-3

Prerequisite: ME 608

Advanced topics in the nonisothermal flow of fluids through channels will be investigated for slug, laminar, transitional and turbulent conditions. The influence of mass transfer on flow and heat transfer processes will be considered. Radiation exchange processes between solid surfaces and solid surfaces and gases both stationary and moving will be discussed.

Mr. Lee.

ME 610. Advanced Topics in Heat Transfer

3-0

Prerequisite: ME 609

This course constitutes a study of recent developments in heat transfer and related areas. It is anticipated that the course content will change from semester to semester.

Mr. Lee.

ME 611, 612. Advanced Machine Design I, II

3-3

Prerequisite: ME 412

Kinematics of mechanical media, the stress tensor, the tensor of strains, elasticity, plasticity, time-dependent behavior; theories of failure, working stresses; shock and steady dynamic loading, creep, stress concentration, thermal stress, contact stresses; energy theories, finite difference and relaxation methods; hydrodynamic lubrication. Application to the design of machine frames, shafts, bearings, gears, springs, cams, etc.

Mr. Zorowski.

ME 613. Mechanics of Machinery

3-0

Prerequisites: ME 312, MA 512

Vector dynamics, d'Alembert's principle, Lagrange's equations; rigid kinematics, Euler's angles, rigid rotation, Coriolis accelerations; the inertia tensor. Application to mechanisms, gyroscopes, guidance and control systems, rotating and reciprocating devices.

Mr. Zorowski.

ME 614. Mechanical Transients and Machine Vibrations

0-3

Prerequisites: ME 312 or EM 545, MA 512

Dynamic loads in mechanical media are considered in two categories: steady vibrations and transient shock and impact. The Lagrange equations and the wave equation are employed to study internal stresses and displacements in mechanical devices which result from such loading.

Mr. Zorowski.

ME 615. Aeroelasticity I

3-0

Prerequisites: MA 541, ME 411 or ME 459, ME 521

Deformations of aero structures under static and dynamic loads, natural mode shapes and frequencies; two and three dimensional incompressible flow;

wings and bodies in unsteady flow; static aeroelastic phenomena.

Mr. Hassan.

ME 616. Aeroelasticity II

0-3

Prerequisites: MA 511, ME 615

Flutter; dynamic response phenomena such as transient landing stresses, gusts, continuous atmospheric turbulence; aeroelastic model theory, model design and construction.

Mr. Hassan.

ME 617. Plates and Shells in Mechanical Design

0-3

Prerequisites: MA 511, ME 611

The concept of members which are thin in one dimension, that is, plates and shells, is applied to mechanical design with particular emphasis on type of loading, conditions of service, and compliance of the member to its environment.

Mr. Zorowski.

ME 631. Applications of Ultrasonics to Engineering Research

3-0

Prerequisites: MA 511, EE 332

The technique and theory of propagation of ultrasonics in liquids, gases and solids. Development of ultrasonic transducers, the elastic piezoelectric, and dielectric relationships. Ultrasonic applications of asdic or sonar, cavitation, emulsification, soldering, welding, and acoustic properties of gases, liquids and solids.

Mr. Woodburn.

ME 641. Mechanical Engineering Seminar

1 or 1

Faculty and graduate student discussions centered around current research problems and advanced engineering theories.

Graduate Staff.

ME 642. Advanced Topics in Mechanical Engineering

1 to 6

Prerequisite: Graduate Standing

Faculty and graduate student discussions of advanced topics in contemporary Mechanical Engineering.

Graduate Staff.

ME 645. Mechanical Engineering Research

3 to 6

Prerequisite: Graduate standing in ME and approval of adviser

Individual research in the field of Mechanical Engineering.

Graduate Staff.

ME 651. Principles of Fluid Motion

3-0

Prerequisite: ME 453

Corequisite: MA 511

Fundamental principles of fluid dynamics. Mathematical methods of analysis are emphasized. Potential flow theory development with introduction to the effects of viscosity and compressibility. Two dimensional and three dimensional phenomena are considered.

Mr. Pinkerton.

ME 652. Dynamics of Compressible Flow

0-3

Prerequisite: ME 651

Properties of compressible fluids, equation of motion of one-dimensional motion, channel flows, shock wave theory, methods of observation, and flows at transonic speeds.

Mr. Pinkerton.

ME 653. Supersonic Aerodynamics

3-0

Prerequisite: ME 652

Equations of motion in supersonic flow, Prandtl-Meyer turns, method of characteristics, hodograph plane, supersonic wind tunnels, supersonic airfoil theory, and boundary layer shock interaction.

Mr. Yen.

ME 654. Dynamics in Viscous Fluids

0-3

Prerequisite: ME 651

Development of the Navier-Stokes equations and the boundary layer theory. Laminar and turbulent boundary layers in theory and experiment, flow separation, and transition.

Mr. Hassan.

ME 660. Aero-Mechanical Engineering Problems

0-3

Prerequisites: ME 502, MA 514, 543 or equivalent

Derivation of governing equations and set up of representative problems

in heat transfer, gas dynamics and magneto-hydrodynamics; review of techniques for solving these problems. Introduction of other techniques such as method of steepest descent, method of Weiner-Hopf, variational methods and others. Phase-space and function space concepts will be introduced also. Purpose of the course in the graduate program to strengthen the analytical techniques of the students in dealing with aero-mechanical engineering problems so that in their later studies more emphasis may be put on formulation of new problems and physical interpretation of new results.

Mr. Yen.

ME 661, 662. Aerospace Energy Systems

3-3

Prerequisites: MA 512, ME 521, PY 407 or equivalent

A study of energy systems appropriate to the varied requirements of space operations. Includes analysis of chemical, nuclear and solar energy sources and the theory of their adaptation to operational requirements for propulsion and auxiliary power, cooling requirements, coolants and materials.

Mr. Truitt.

ME 671, 672. Advanced Air Conditioning Design I, II

3-3

Prerequisites: ME 571, ME 572

The design of heating and air conditioning systems; the preparation of specifications and performance tests on heating and air conditioning equipment.

Mr. Knight.

ME 691, 692. Advanced Spacecraft Design

3-3

Prerequisites: ME 542, ME 582

Analysis and design of spacecraft including system design criteria, acceleration tolerance, entry environment, thermal requirements, criteria for configuration design, aerodynamic design, heating rates, thermostructural design, boost phase, de-orbit, entry corridor, lift modulation, rolling entry, glide phase, maneuvering and landing, stability and control, thermal protection system, materials, instrumentation, and life support systems.

Mr. Truitt.

METALLURGICAL ENGINEERING

See Department of Mineral Industries

DEPARTMENT OF MINERAL INDUSTRIES

Graduate Faculty

Professors: WILLIAM WYATT AUSTIN, *Head*, WILLIAM CALLUM BELL, WILLIAM WURTH KRIEGLER, JOHN MASON PARKER, III, HANS HEINRICH STADELMAIER, ROBERT FRANKLIN STOOPS

Associate Professors: WILLIAM CULLEN HACKLER, CARLTON JAMES LEITH, HAYNE PALMOUR, III

Assistant Professor: HENRY SEAWELL BROWN

The Department of Mineral Industries offers graduate programs leading to the degrees of Master of Science in ceramic engineering, geological engineering, and metallurgical engineering, and to the Doctor of Philosophy degree in ceramic engineering. Certain graduate courses are also offered for the benefit of students majoring in other areas who may be interested in pursuing advanced work in the mineral industries fields.

Ceramic Engineering

The graduate program in ceramic engineering includes study and research in the following sub-divisions: physical ceramics, electrical ceramics, glass, vitreous enamels and coatings, structural clay products, refractories, white-ware and materials associated with nuclear reactor programs.

The prerequisite for graduate work in ceramic engineering is a proficiency in the undergraduate courses required for the bachelor's degree in ceramic engineering, or substantial equivalent.

The department's ceramic laboratories are well equipped for research work. These facilities are augmented by those of the Ceramic Research Laboratories of the Department of Engineering Research. Also available are the Electron Microscope and X-Ray Diffraction Laboratories of that department, and the Nuclear Reactors of the Physics Department.

Illustrative of the scope of graduate research in ceramics at North Carolina State College are some of the recent and current projects. These have encompassed studies of the dielectric and physical characteristics of ceramic bodies in the system BaTiO_3 , mechanical properties of single crystal sapphire, and spinel, mechanical properties and deformation mechanisms in polycrystalline spinel, studies of the power losses in low dielectric constant ceramics, the effect of devitrification of the glassy phase on the conductivity of ceramic insulator bodies, studies in spodumene, tremolite, tale, and nepheline syenite in multiffux vitreous bodies, diffusion of selected isotopes through ceramic and cermet bodies, and the effect of alkali on the hygroscopicity of glass, studies of the maximum safe rate of drying structural clays, and the pozzolanic properties of shale.

Geological Engineering

The graduate program in geological engineering is directed to the advanced training of qualified students interested in the professional economic applications of geological knowledge. The occupational fields include the locating of mineral resources, and the assessing of geological conditions at the sites of large civil engineering projects. Candidates for admission to this program should hold the Bachelor of Geological Engineering degree or a satisfactory equivalent, preferably including a strong background in physics, chemistry, and engineering sciences.

The solution of professional problems in geology is today requiring more specialized training and quantitative methods than can be included in an under-graduate curriculum. A person with such training in geology finds employment with petroleum, mining, and construction companies, governmental agencies, and educational research institutions.

A great variety of problems in igneous, sedimentary, and metamorphic geology are to be found within a radius of fifty miles of North Carolina State College.

Facilities are available for research in mineralogy, petrography, economic geology, mineral dressing, and geologic problems relating to civil engineering. Excellent collections of geological literature are available at State College, at the University of North Carolina at Chapel Hill, and at Duke University in Durham. A well staffed unit of the Ground Water division of the U. S.

Geological Survey is housed nearby on the campus and is available for consultation.

Metallurgical Engineering

The rapid development of space and nuclear technology and attendant materials problems has brought about a sharp increase in the demand for trained leaders in the materials fields. There is at present intense emphasis on advanced study and research on the fundamental behavior of metals and alloys. From this work will come urgently-needed improvements in metallic materials of construction to withstand increasingly drastic service requirements—higher stresses, higher temperatures, corrosive and radioactive environments.

Opportunities for men with graduate training in metallurgy and metallurgical engineering are almost unlimited. Industry and universities today need approximately four times as many metallurgists with advanced degrees as are available. It has been estimated that by 1975 the electrical, chemical, aircraft, and nuclear industries will require 50,000 research metallurgists and metallurgical engineers. The number presently available is approximately 5,000. Present ratios indicate that one-third to one-half of the 50,000 graduates needed should have advanced training beyond the bachelor's degree. The shortage of graduates with advanced degrees is further accentuated by the need for qualified college faculty members to provide adequate instruction in metallurgical and related fields.

North Carolina State College is one of the few institutions in the South, and the only institution in North Carolina, prepared to offer graduate instruction in metallurgical engineering. In addition to the advanced work in metallurgical engineering, the School of Engineering also offers an excellent program of supporting courses at the graduate level in the related fields of physics, chemistry, mathematics, engineering mechanics, and in mechanical, chemical, ceramic, and nuclear engineering.

Financial assistance is available to graduate students in the Department of Mineral Industries. Graduate assistantships permit half-time studies in either ceramic engineering, geological engineering, or metallurgical engineering, and half time to be devoted to teaching or other assigned duties. Also, certain sponsored fellowships that permit full time to be devoted to graduate studies, such as the Edward Orton, Jr. Ceramic Foundation Fellowship and the Ford Foundation Fellowship, are available. Applications should be made to the department.

Ceramic Engineering

Courses for Advanced Undergraduates

MIC 413. Ceramic Process Principles II

4-0

Prerequisites: MIC 312 and CH 342

A continuation of MIC 312. Introduction to crystal chemistry and the constitution of glass. Consideration of special problems relating to glasses, glazes and equilibria with particular reference to refractories.

MIC 414. Senior Thesis

3-3

One semester required of seniors in Ceramic Engineering

A second semester may be elected

An introduction to research. Literature search, laboratory investigation and written report in the form of a thesis. Conference and laboratory.

MIC 415, 416. Ceramic Engineering Design 2-2

The methods of ceramic equipment, structure and plant design.

MIC 420. Industrial Ceramics 3-0

A study of the various ceramic industries, including manufacturing techniques, labor and professional relationships, and the present and future status of the respect industries. Lectures and discussion.

MIC 425. Seminar 1-1

One semester required of seniors in Ceramic Engineering

A second semester may be elected

Literature survey of selected topics in ceramic engineering. Oral and written reports, discussions.

Courses for Graduates and Advanced Undergraduates

MIC 503. Ceramic Microscopy 3 or 3

Prerequisite: MIG 531

Petrographic techniques for the systematic study of ceramic materials and products. Interpretation and representation of results. Mr. Kriegel.

MIC 505. Research and Control Methods 0-3

Prerequisite: MIC 413

Lectures, demonstrations and experiments on instrumental methods of ceramic investigation and statistical methods of control. Mr. Hackler.

MIC 507, 508. Advanced Ceramic Experiments 3-3

Prerequisite: MIC 414 or equivalent

Advanced studies in ceramic laboratory experimentation. Graduate Staff.

MIC 511. Advanced Studies in Firing 3 or 3

Prerequisite: MIC 413

Advanced studies of ceramic firing procedures with emphasis on the design, calculation and economic evaluation of kilns and furnaces.

Mr. Hackler.

MIC 522. Structural Clay Products 0-3

Prerequisite: MIC 413

The technology of the structural clay products industries with emphasis on the latest developments in the field. Mr. Kriegel.

MIC 527. Refractories in Service 3 or 3

Prerequisite: CH 342

A study of the physical and chemical properties of the more important refractories in respect to their environment in industrial and laboratory furnaces. Mr. Kriegel.

MIC 540. Glass Technology 3 or 3

Prerequisite: MIC 413

Fundamentals of glass manufacture including compositions, properties and application of the principle types of commercial glass. Mr. Hackler.

MIC 548. Technology of Cements 0-3

Prerequisite: MIC 413

The technology of the Portland cement industry including manufacture, control and uses. Mr. Kriegel.

Courses for Graduates Only

MIC 601. Ceramic Phase Relationships 3 or 3

Prerequisite: Consent of Instructor

Heterogeneous equilibrium, phase transformations, dissociation, fusion, lattice energy, defect structure, thermodynamic properties of ionic phases and silicate melts. Mr. Hackler.

MIC 605, 606. Crystal Structures**2-2**

Prerequisite: CH 342

Basic laws of crystal structure. Relation of crystal structure to chemical and physical properties.

Messrs. Hackler, Kriegel.

MIC 613. Ceramic Thermal Mineralogy**0-3**

Prerequisite: MIC 605

Applications of the principles of thermal chemical mineralogy to ceramic problems.

Mr. Stoops.

MIC 615, 616. High Temperature Technology**3-3**

Prerequisite: MIC 613

An advance consideration of the generation of high temperatures, furnace designs and atmosphere controls.

Theory of sintering, hot pressing and thermo-chemical properties of high-temperature materials.

Mr. Stoops.

MIC 650. Ceramic Research**Credits by arrangements**

An original and independent investigation in ceramic engineering. A report of such an investigation is required as a graduate thesis.

Graduate Staff.

MIC 660. Ceramic Engineering Seminar**1-1**

Reports and discussion of special topics in ceramic engineering and allied fields.

Graduate Staff.

MIC 661. Special Studies in Ceramic Engineering**1 to 3 credits
per semester**

Special studies of advanced topics in ceramic engineering. Credit will vary with the topic.

Graduate Staff.

Geological Engineering**Courses for Advanced Undergraduates****MIG 415. Mineral Exploration and Evaluation****0-3**

Prerequisite: MIG 440, MIG 452

Application of the principles of geology, geophysics, and geochemistry to the discovery and evaluation of mineral deposits. Design of mineral exploration and development programs based on knowledge of the unique thermodynamic, geochemical, and tectonic features that control mineral formation and concentrations in well known mining districts, especially those yielding ferrous, base, and precious metals. Review of economic and technological factors governing the value of mineral deposits.

MIG 440. Endogenic Materials and Processes**0-4**

Prerequisites: MIG 220, MIG 331

Minerals, rocks, and mineral deposits that are formed at high temperatures and pressures by crystallization or solidification of molten magma, or by solid state recrystallization of older rocks. Application of principles of thermodynamics and of phase-rule chemistry, and the results of modern high pressure-temperature laboratory research on the stability fields of crystalline phases, to an understanding of igneous and metamorphic rocks. Identification, classification, occurrence, origin, and economic value of the principal igneous and metamorphic rocks.

MIG 452. Exogenic Materials and Processes**4-0**

Prerequisites: MIG 220, MIG 331

Identification, classification, geologic occurrence, origin, and economic value of minerals, rocks, and mineral deposits formed by physical, chemical, and biological processes at low temperatures and pressures at and near the earth's surface. Hydrodynamics of sediment transport and deposition, settling velocities and size sorting, chemical and biochemical precipitation from

aqueous solutions, principles of division of stratified terranes into natural units, correlation of strata, identification of depositional environments, and facies analysis.

MIG 461. Engineering Geology

3 or 3

Prerequisite: MIG 120 or 220

Required in fifth year of Geological Engineering

The application of geologic principles to engineering practice; analysis of geological factors and processes affecting specific engineering projects.

Mr. Leith.

MIG 462. Geological Surveying

0-3

Prerequisites: MIG 351 and 440

Required of seniors in Geological Engineering

Methods of field observation and use of geologic surveying instruments in surface and underground work; representation of geologic features by maps, sections and diagrams. Lectures, laboratories, and field work.

Mr. Parker.

MIG 465. Geological Field Procedures

6 Summer

Prerequisite: MIG 351 or special permission

A six week summer field course. Practical field procedures and instruments commonly used to procure geologic data for evaluating mineral deposits, solving engineering problems involving earth materials, and drawing scientific conclusions. Observation of geologic phenomena in their natural setting. Large and intermediate scale geologic mapping of surface features and large scale mapping underground in mine workings.

MIG 472. Elements of Mining Engineering

3-0

Prerequisite: MIG 220 and at least Junior standing in Geological Engineering.

Introduction to mining; surface and underground methods of development and production; explosives, drilling and blasting; ore loading, transport, and hoisting; drainage and ventilation; mine surveying and sampling; fire assaying; mining law, organization, administration, and safety. Lectures, laboratory and field inspections.

Courses for Graduates and Advanced Undergraduates

MIG 522. Petroleum Geology

3 or 3

Prerequisite: MIG 452

Required in fifth year of Geological Engineering

Properties, origin and modes of occurrence of petroleum and natural gas. Geologic and economic features of the principal oil and gas fields, mainly in the United States.

Mr. Leith.

MIG 552. Exploratory Geophysics

0-3

Prerequisites: MIG 351, PY 202

Fundamental principles underlying all geophysical methods; procedure and instruments involved in gravitational, magnetic, seismic, electrical, and other methods of studying geological structures and conditions. Spontaneous potential, resistivity, radioactivity, temperature, and other geophysical logging methods. Study of applications and interpretations of results.

MIG 571, 572. Mining and Mineral Dressing

3-3

Prerequisite: MIG 472

Required in fifth year of Geological Engineering

Principles of the mineral industry; mining laws, prospecting, sampling,

development, drilling, blasting, handling, ventilation and safety; administration, surveying, assaying; preparation, beneficiation and marketing.

Graduate Staff.

MIG 581. Geomorphology

3-0

Prerequisite: MIG 452

Required in fifth year of Geological Engineering.

A systematic study of land forms and their relations to processes and stages of development and adjustment to underlying structure. Lectures, map interpretations, and field trips.

Mr. Brown.

Courses for Graduates Only

MIG 611, 612. Advanced Economic Geology

3-3

Prerequisites: MIG 440 and 445

Required in fifth year of Geological Engineering.

Detailed study of the origin and occurrence of specific mineral deposits.

Mr. Brown.

MIG 632. Microscopic Determination of Opaque Minerals

3 or 3

Prerequisite: MIG 331

Identification of metallic, opaque minerals in polished sections by physical properties, etch reactions and microchemical tests. Laboratories.

Mr. Brown.

MIG 642. Advanced Petrography

3 or 3

Prerequisites: MIG 331 and 440

Application of the petrographic microscope to the systematic study of the composition and origin of rocks; emphasis on igneous and metamorphic rocks.

Mr. Parker.

MIG 681, 682. Seminar

1-1

Prerequisite: Graduate standing

Scientific articles, progress reports and special problems of interest to geologists and geological and mining engineers discussed.

Graduate Staff.

MIG 691. Geological Research

Credits by arrangement

Prerequisite: Permission of the Instructor

Lectures, reading assignments, and reports; special work in Geology to meet the needs and interests of the students.

Graduate Staff.

Metallurgical Engineering

MIM 401, 402. Metallurgical Operations I, II

4-4

Prerequisite: MIM 332

A systematized treatment of the fundamental operations involved in the production and fabrication of metals and alloys. Part I deals primarily with procedures and operations employed in chemical or extractive metallurgy. Part II covers the operations of physical and mechanical metallurgy.

Staff.

MIM 421, 422. Metallurgy I, II

2-2

Prerequisite: CH 102

Required of seniors in M.E. and M.E.A.

The constitution, structure and properties of engineering ferrous and non-ferrous metals and alloys; influences of mechanical working and heat treatment; physical testing, corrosion and its prevention.

Staff.

MIM 423. Metallurgical Laboratory

1 or 1

Corequisite: MIM 421 or 422

Laboratory work to accompany Metallurgy I, II.

Staff.

MIM 431, 432. Metallography I, II

3-3

Prerequisite: MIM 332

An intensive study of the principles and techniques for examination and

correlation of the structure, constitution, and properties of metals and alloys. Staff.

MIM 451, 452. Metallurgical Engineering Seminar 1-1

Prerequisite: Senior standing in Met.E.

Reports and discussion of special topics in metallurgical engineering and related subjects. Staff.

Courses for Graduates and Advanced Undergraduates

MIM 521, 522. Advanced Physical Metallurgy I, II 3-3

Prerequisite: MIM 422

Theories concerning behavior and control of engineering alloys, reaction rates in the solid state, and alloy influences; current heat treating practices; surface treatments; behavior of metals at high and low temperatures; special purpose alloys; powder metallurgy; review of modern equipment and methods for the study of metals. Mr. Stadelmaier.

MIM 523, 524. Metallurgical Factors in Design 3-3

Prerequisite: MIM 422

A study of the metallurgical factors that must be considered in using metals in design. Mr. Austin.

MIM 541, 542. Principles of Corrosion I, II 3-3

Prerequisite: MIM 422

The fundamentals of metallic corrosion and passivity. The electro-chemical nature of corrosive attack, basic forms of corrosion, corrosion rate factors, methods of corrosion protection. Laboratory work included. Mr. Austin.

MIM 545, 546. Advanced Metallurgical Experiments I, II 3-3

Prerequisite: MIM 422 or approval of instructor

Advanced engineering principles applied to a specific experimental project dealing with metallurgy or metallography. A seminar period is provided, and a written report is required. Graduate Staff.

MIM 561. Advanced Structure and Properties of Materials 3-0

Prerequisite: MIM 422

A systematic treatment of the fundamental physico-chemical principles governing the constitution of both metallic and ceramic materials. Correlation of these principles with physical, mechanical and chemical properties of materials. Particular emphasis is placed upon materials of construction for nuclear reactors. Lecture and Laboratory. Mr. Austin.

MIM 562. Materials Problems in Nuclear Engineering 0-3

Prerequisite: MIM 561

Engineering aspects of problems involved in the selection and application of reactor materials. Specific attention is given to elevated temperature behavior, fatigue, corrosion, irradiation damage, and the fabrication and processing of these materials. Lecture and Laboratory. Graduate Staff.

Courses for Graduates Only

MIM 651, 652. Theory and Structure of Metals 3-3

Prerequisite: MIM 522

An advanced interpretation of the development of theories of the metallic state with emphasis on modern physical concepts. Topics include theory of crystallinity, bonding forces, stability of metallic structures, diffusion, and dislocation theory. Mr. Stadelmaier.

MIM 695. Metallurgical Engineering Research Credits by arrangement

Independent investigation of an appropriate problem in Metallurgical Engineering. A report on this investigation is required as a graduate thesis. Graduate Staff.

DEPARTMENT OF MODERN LANGUAGES**Graduate Faculty**

Professor: GEORGE W. POLAND, Head

The Department of Modern Languages courses listed below are recommended to assist graduate students in preparing themselves for the use of modern foreign languages in research and advanced study. Students are given the opportunity of working a translation project in connection with their subject of major interest. They are encouraged particularly to seek in this instance useful foreign research related to thesis or other research in progress. Although these courses do not carry graduate language credit, they may be taken as a means of attaining a reading knowledge.

Certification may be obtained in languages not normally taught by the department with special permission of the Graduate School.

MLR 101, 102(G). Russian **3-3**
These two courses are given for graduate students only, the first dealing with grammar and structure and the second, with reading of Russian scientific material.

MLF 401. Introductory Scientific French **3-3**
This course is designed to present the grammar of scientific French as rapidly as possible in preparation for the reading course which follows.

MLF 402. Introductory Scientific French **3-3**
Prerequisite: MLF 401 or equivalent
Reading and translation of technical French, supplemented by discussions on terminology, word order, vocabulary analysis and other linguistic techniques. Subject material adjusted to individual needs; conferences.

MLS 401. Introductory Scientific Spanish **3-3**
This course is designed to present the grammar of scientific Spanish as rapidly as possible in preparation for the reading course which follows.

MLS 402. Introductory Scientific Spanish **3-3**
Prerequisite: MLS 401 or equivalent
Reading and translation of technical Spanish, supplemented by discussions on terminology, word order, vocabulary analysis and other linguistic techniques. Subject material adjusted to individual needs; conferences.

MLG 401. German Grammar for Graduate Students **3-3**
This course is designed to present the grammar of scientific German as rapidly as possible in preparation for the reading course which follows.

MLG 402. Scientific German **3-3**
Prerequisite: MLG 401
Reading and translation of technical German, supplemented by discussions on terminology, word order, vocabulary analysis and other linguistic techniques. Subject material adjusted to individual needs; conferences.

DEPARTMENT OF NUCLEAR ENGINEERING

Professor: HAROLD AUGUSTUS LAMONDS, Head

The Department of Nuclear Engineering offers graduate work leading to the Master of Science and Doctor of Philosophy degrees in nuclear engineering.

Courses are available for specialization in several areas of nuclear engineering including reactor theory, energy transfer, nuclear materials, and

nuclear instrumentation. Established in 1949, the nuclear engineering program has undergone a steady increase in the number and intensity of associated course offerings, and presently offers a well-rounded program of instruction.

Candidates for admission are expected to have earned a bachelor's degree in one of the physical sciences or branches of engineering at a recognized college or university. A knowledge of nuclear physics, advanced differential equations and elementary reactor theory at the senior level will reduce the time required for completion of the degree. Students without this preparation will be able to take the needed courses in the initial phases of their graduate program.

A minimum of thirty credits at the graduate level is required for the Master of Science degree. Up to four of these credits will be allowed for completion of a thesis in some phase of nuclear technology. The remainder of the study plan is developed to suit individual interests and backgrounds rather than follow a set curriculum.

The Doctor of Philosophy degree is awarded upon successful completion of the preliminary examinations and a dissertation.

Major research facilities available on campus for student use include a tank-type heterogeneous reactor, a water-boiler type homogeneous reactor, a sub-critical assembly, a pulsed, positive-ion Van de Graaff accelerator, and an IBM 650 computer.

A limited number of teaching and research assistantships are available. Half-time assistantships pay \$2,400 for ten months' service. The College is also an authorized institution for holders of NSF Graduate Fellowships and AEC Special Fellowships in Nuclear Science and Engineering. These may be applied for directly by writing to:

The Fellowship Office
Oak Ridge Institute of Nuclear Studies
Oak Ridge, Tennessee

or

The Fellowship Office
National Academy of Sciences
National Research Council
2101 Constitution Avenue, N.W.
Washington 25, D. C.

North Carolina State College has recently received a grant from the Ford Foundation to support pre-doctoral students preparing for an academic career. Fellowships provided from this grant range up to \$2,200 per year for full-time study and are renewable up to a total of three years. In addition, forgivable loans of up to \$3,000 per year are available from the fund. Applications for these fellowships should be made to:

The Dean of Engineering
N. C. State College
Raleigh, N. C.

Courses for Advanced Undergraduates

NE 501. Nuclear Engineering Systems I

3-0

Corequisite: PY 410

An introductory course in reactor theory and engineering including the

fission process; neutron energy distribution; lethargy; neutron slowing, diffusion and interactions; Fermi age theory; the diffusion equation, criticality conditions reactor instrumentation. Mr. Lamonds.

NE 502. Nuclear Engineering Systems II 0-3

Prerequisite: NE 501

Course considers reactor as a system including aspects of reactor control, radiation protection, shielding and thermal design. Mr. Lamonds.

NE 503. Nuclear Reactor Theory I 0-3

Prerequisite: NE 501

Continuation of reactor theory from NE 501. Topics include: treatment of reactor parameters for homogeneous and heterogeneous reactors; reflected reactors, two-group theory, reactor kinetics, temperature effects, control rod theory, perturbation theory and transport theory. Mr. Lamonds.

NE 530. (PY 530) Introduction to Nuclear Reactor Theory 0-3

See PY 530.

NE 531. (PY 531), Nuclear Reactor Laboratory 1-1

See PY 531.

Courses for Graduates Only

NE 619. (PY 619), Reactor Theory and Analysis I 3-0

See PY 619.

NE 620. (PY 620), Nuclear Radiation Attenuation 3-0

See PY 620.

NE 630. (PY 630), Reactor Theory and Analysis II 0-3

See PY 630.

DEPARTMENT OF OCCUPATIONAL INFORMATION AND GUIDANCE

(See School of Education)

DEPARTMENT OF PHILOSOPHY AND RELIGION

PHI 401. Symbolic Logic 3 or 3

Modern methods in logic involving formalized expression that avoids inherent difficulties and ambiguities of ordinary language and makes possible greater effectiveness in handling complex material.

REL 403. Religions of the World 3 or 3

Background, general characteristics, and basic teachings of the major living religions of the world; consideration of contemporary secular movements that are in a sense religions.

PHI 405. Foundations of Science 3 or 3

Nature and validity of knowledge, basic concepts of modern science, scientific method, and the implications of the philosophy of modern science for ethics, social philosophy, and the nature of reality.

DEPARTMENT OF PHYSICS

Graduate Faculty

Professors: RAYMOND LEROY MURRAY, *Head*, WILLARD HARRISON BENNETT, FORREST WESLEY LANCASTER, JEFFERSON SULLIVAN MEARES, ARTHUR CLAYTON, MENIUS, JR., RUFUS HUMMER SNYDER, NEWTON UNDERWOOD, ARTHUR W. WALTNER

Associate Professors: WESLEY OSBORNE DOGGETT, JOSEPH THOMAS LYNN,
Graduate Administrator

Assistant Professors: WILLIAM PAUL BUCHER, GROVER CLEVELAND COBB, JR.,
WILLIAM ROBERT DAVIS, RAOUL M. FREYRE, DAVID HAMILTON MARTIN

Study in applied physics leading to the degrees Master of Science and Doctor of Philosophy is available. Courses, staff, and facilities are provided for presentation of the fundamental subject matter of physics and for specialized study and research in several areas, as listed below:

- (a) Nuclear physics: Theory and experimental work in low-energy charged-particle physics, neutron physics.
- (b) Space physics: Research on phenomena in the outer atmosphere and interplanetary space.
- (c) Plasma physics: Studies of basic ionic processes and applications to direct electrical conversion systems and thermonuclear research.
- (d) Nuclear science: The theory of chain reacting systems, radiation hazards and protection, and radiation attenuation in matter.
- (e) Theoretical physics: The theory of fields, non-inertial systems, plasmas, and nuclear reactions.

For additional information relating to research, design and development aspects of nuclear technology, reference should be made to the offerings in the nuclear engineering curriculum.

Recommended programs of study with emphasis on fundamental physics or on nuclear science leading to the Master of Science degree are available. A minimum of 30 semester credits is required, which is to include 4 credits for research and 2 for seminar. Research and presentation of a thesis are required. Graduates are prepared for research and development activity in general physics or in the space, missile and energy conversion programs of our country.

The Doctor of Philosophy degree is granted on successful completion of examinations, independent research, and the preparation of a dissertation. A minor in mathematics or other area in science is conventional.

Extensive laboratory facilities are available for research in the areas of specialization. These facilities include:

- (a) An enriched uranium heterogeneous water-moderated nuclear reactor, with power up to 100 kilowatts, for study of neutron physics and nuclear reactions.
- (b) A research and training laboratory in radiation hazards and protection is provided in conjunction with the reactor.
- (c) A low power homogeneous enriched uranium "water-boiler" reactor, for study of the fission process.
- (d) A 2500 kg natural uranium subcritical assembly.
- (e) A one mev Van de Graaff accelerator with pulsing equipment for study of neutron scattering, polarization, and diffusion.
- (f) A hypersonic ionic wind tunnel for study of simulated space environments.
- (g) Fully equipped laboratories for the investigation of the stability of ionic streams and the measurement of plasma phenomena by ultrasonic methods.
- (h) Laboratories for research in magneto-optical effects, radiation detection, radiation dosimetry, and positronium research.

- (i) High speed digital computing facilities including the IBM 650 at Raleigh and the Remington Rand UNIVAC 1105 at Chapel Hill.

The Department of Physics participates in the Nuclear Science and Engineering Fellowship program of the Atomic Energy Commission; and Fellowships in Health Physics are currently available under a continuing grant from the U. S. Public Health Service. Students are eligible for fellowships from the Ford Foundation, the National Science Foundation, and others. Research assistantships are available supported by grants or contracts with federal agencies. A number of openings for halftime teaching assistantships in general and intermediate physics is available each year.

Courses for Advanced Undergraduates

PY 401. Mechanics 4-0

Prerequisite: PY 202; Corequisite: MA 301

An intermediate course in theoretical mechanics. Dynamics of particles and rigid bodies with an introduction to advanced dynamics. Lagrange's equations and simple applications, Lorentz transformations and an introduction to the theory of special relativity. Mr. Moss.

PY 402. Heat and Sound 0-4

Prerequisite: PY 202; Corequisite: MA 301

An intermediate course in the principles of thermodynamics, kinetic theory, heat transfer, and vibrations. Mr. Moss.

PY 403. Electricity and Magnetism 4-0

Prerequisite: PY 202; Corequisite: MA 301

An intermediate course in the fundamentals of static and dynamic electricity, and electromagnetic theory. Mr. Doggett.

PY 404. Optics 0-4

Prerequisite: PY 202; Corequisite: MA 301

An intermediate course in physical and geometrical optics. Mr. Doggett.

PY 407. Introduction to Modern Physics 3-3

Prerequisites: PY 202, MA 202

A survey of the important developments in atomic and nuclear physics of this century. Among topics covered are: atomic and molecular structure, determination of properties of ions and fundamental particles, the origin of spectra, ion accelerators, and nuclear reactions. Staff.

PY 410. Nuclear Physics I 4-4

Prerequisite: PY 407

An introduction to the properties of the nucleus, and the interaction of radiation with matter. A quantitative description is given of natural and artificial radioactivity, nuclear reactions, fission, fusion, and the structure of simple nuclei. Mr. Waltner.

PY 491. Senior Research 3-3

Prerequisite: Senior Honors program standing, except with special permission

Investigations in physics under the guidance of staff members. Literature reviews, experimental measurements, or theoretical studies. A project report will be prepared. Staff.

Courses for Graduates and Advanced Undergraduates

PY 501. Wave Mechanics 0-3

Prerequisites: PY 407, MA 511, and either PY 401 or PY 403

An introduction to the foundations of quantum and wave mechanics, with solutions of the problems of the free particle, harmonic oscillator, rigid rotating molecule, and the hydrogen atom. Approximation methods are developed for more complex atomic systems. Mr. Cobb.

PY 503. Introduction to Theoretical Physics**3-0**

Prerequisites: PY 401 or PY 403, MA 511

An introductory course which offers preparation necessary for advanced graduate study, presented from the viewpoint of vector and tensor calculus. Particle dynamics, Lagrange's equations of motion, Hamilton's principle, mechanics of rigid bodies, topics in electromagnetic theory and relativity, with an elementary treatment of the motion of charged particles.

Mr. Freyre.

PY 507. Advanced Atomic Physics**3-0**

Prerequisites: PY 401, PY 403, MA 511

A study of atomic structure and spectra, with emphasis on the analysis of spectra. Topics include: the alkali spectra, multiplet structure, electron spin, hyperfine structure, moments, etc.

Mr. Cobb.

PY 508. Ionization in Gases**3-0**

Prerequisites: PY 401, PY 403, MA 301

Statistical theory of matter; excitation and ionization in gases; mobilities and conductivities; processes at solid surfaces in ionized gases; characteristic forms of electrical discharges in gases.

Mr. Bennett.

PY 509. Plasma Physics**0-3**

Prerequisite: PY 508

Individual and collective motion of charged particles in electric and magnetic fields and through ionized gases. Pinch effect, relativistic streams, conductivities, and runaway electrons. Astrophysical concepts and approximations. Properties of plasmas, including waves, confinement, instabilities and shocks, with applications.

Mr. Bennett.

PY 510. Nuclear Physics II**4-0**

Prerequisite: PY 410

The description and analysis of nuclear energy levels, meson theory, nuclear resonance, atomic and molecular magnetism, and cosmic radiation. Principles and experiments in neutron physics are discussed. In the laboratory work, emphasis is placed on gaining experience in independent research.

Mr. Waltner.

PY 518. Radiation Hazard and Protection**3-3**

Prerequisite: PY 410

The hazards from external exposure to ionizing radiation are evaluated, and the factors influencing dosage due to internal exposure are investigated. Methods of providing protection are analyzed.

Mr. Underwood.

PY 520. Physical Measurements in Radioactivity**3-3**

Prerequisite: PY 410

The principles of experimental measurements on radioactive materials are presented and demonstrated through laboratory work. Emphasis is placed on preparation of samples for precise quantitative study, detection of radiations, and analytical interpretation of experimental data.

Mr. Lynn.

PY 530. (NE 530) Introduction to Nuclear Reactor Theory**0-3**

Prerequisites: PY 410, MA 401 or MA 511

The principles of neutron motion in matter, with emphasis on the analysis of the nuclear chain reactor. Slowing of neutrons, diffusion, space distributions of flux, conditions for criticality, group theories, and the time dependent behavior of fissionable assemblies.

Mr. Murray.

PY 531. (NE 531) Nuclear Reactor Laboratory**1-1**

Corequisites: PY 518, PY 530

Observation and measurements of static and dynamic nuclear reactor behavior, the effectiveness of control and temperature, and correlation with theory. Experiments on the motion and detection of neutrons and gamma rays, with emphasis on the research uses of nuclear reactor radiations.

Graduate Staff.

PY 541. Special Problems in Physics**1-3 credits by arrangement**

Prerequisite: Permission of department

Study and research in special topics of classical and modern physics. Experimental measurements with emphasis on the treatment and interpretation of data, literature surveys, or theoretical investigations.

Graduate Staff.

PY 552. Introduction to the Structure of Solids**0-3**

Prerequisites: PY 202, MA 202; PY 403 and PY 407 are recommended

Basic considerations of amorphous and crystalline solids, metals, conductors, and semi-conductors.

Mr. Doggett.

PY 555. (MA 555) Principles of Astrodynamics**3-3**

Prerequisites: MA 511; PY 401 or EM 312

The differential equations of motion in two-body problems and their integrals; orbit theory; integrals of the n-body problem; differential equations of motion of nature and artificial satellites and their approximate solutions.

Mr. Musen.

PY 601, 602. Advanced General Physics**3-3**

Prerequisite: PY 503; Corequisite: MA 661

Mathematical and theoretical approach to relationships between the various branches of physics, with applications to mechanical, electrical, optical, thermal, and vibratory problems. The restricted theory of relativity, electrodynamics, the theory of electrons, classical field theory, and the general theory of relativity.

Mr. Davis.

PY 610. Advanced Nuclear Physics**0-3**

Prerequisites: PY 501, PY 510

Current hypotheses of nuclear structure and reactions including deuteron binding, neutron-proton scattering, the compound nucleus, stripping reactions, shell structure, beta decay, neutron resonances, and mesons. The use of neutrons in present-day nuclear research is emphasized.

Graduate Staff.

PY 611. Quantum Mechanics**3-0**

Prerequisites: PY 501, MA 512

Theory of quantum mechanics with applications to atomic and molecular structure, scattering phenomena, and a semi-classical treatment of the interaction of radiation with matter.

Mr. Davis.

PY 612. Advanced Quantum Mechanics**0-3**

Prerequisites: PY 601, PY 611

Dirac's relativistic electron theory, elementary scalar and vector meson field theory. Introduction to quantum electrodynamics and the general theory of quantized fields.

Mr. Davis.

PY 617, 618. Principles of Health Physics Measurements**2-2**

Prerequisite: PY 410; Corequisite: PY 518, PY 520 recommended

The physical principles underlying health physics measurements are studied both theoretically and experimentally. The purpose of the course is to develop in the student an insight into the principles and problems involved in measuring radiation and determining dose.

Mr. Underwood.

PY 619. (NE 619) Reactor Theory and Analysis I**3-0**

Prerequisite: PY 530

The theory of neutron slowing, resonance capture, Doppler effect, and thermal flux distributions in heterogeneous nuclear reactors. Analysis of reactor control by temperature, effects of localized and distributed absorbers, fission products, fuel consumption and production. One-velocity neutron transport theory.

Mr. Murray.

PY 620. (NE 620) Nuclear Radiation Attenuation**3-0**

Prerequisites: PY 530, MA 512

Physical theory of the behavior of neutrons, gamma-rays and charged particles in matter. Calculation of source terms, attenuation factors, heating rates, geometrical transformations, radiation streaming and radioactive decay effects required in the design of nuclear radiation shields for reactors, accelerators, and space vehicles. Transport theory of gamma-ray and neutron transmission through matter. Analysis of experimental techniques for obtaining shielding data.

Mr. Doggett.

PY 621. Kinetic Theory of Gases**3-0**

Prerequisites: PY 501, PY 503, and MA 512

The theory of molecular motion, including velocity and density distribution functions; the phenomena of viscosity, heat conduction, and diffusion; equations of state; fluctuations.

Mr. Freyre.

PY 622. Statistical Mechanics**0-3**

Prerequisites: PY 501, PY 503, MA 512, and PY 621

A treatment of statistical mechanics from both the classical and quantum points of view. Development of thermodynamic theories and application to atomic systems.

Mr. Freyre.

PY 630. (NE 630). Reactor Theory and Analysis II**0-3**

Prerequisite: PY 530

The theory of neutron multiplication in uniform media, with several dimensions, regions, and neutron energy groups. Reactor control by absorbers, time dependent reactor behavior, matrix treatment of perturbation theory, neutron thermalization, energy dependent neutron transport theory, and multigroup machine methods.

Mr. Murray.

PY 670. Seminar**1-1**

Literature surveys and written and oral presentation of papers on current topics in (a) general physics, (b) nuclear physics, (c) ionic phenomena of space physics, (d) plasma physics, (e) non-inertial space mechanics.

Graduate Staff.

PY 690. Research**Credits by arrangement**

Graduate students sufficiently prepared may undertake research in some selected field of Physics.

Graduate Staff.

DEPARTMENT OF PLANT PATHOLOGY**Graduate Faculty**

Professors: DON EDWIN ELLIS, *Head*, ROBERT AYCOCK, CARLYLE NEWTON CLAYTON, FRANK ARLO HAASIS, TEDDY THEODORE HEBERT, ARTHUR KELMAN, ELMER LEON MOORE, LOWELL WENDELL NIELSON, CHARLES JOSEPH NUSBAUM, NASH NICKS WINSTEAD

Professor Emeritus: SAMUEL GEORGE LEHMAN

Associate Professors: JAY LAWRENCE APPLE, WILLIAM EARL COOPER, GEORGE BLANCHARD LUCAS, RICHARD ROBERT NELSON, JOHN PAUL ROSS, JOSEPH NEAL SASSER, HEDWIG HIRSCHMANN TRIANTAPHYLLOU.

Assistant Professors: DAVID M. KLINE, NATHANIEL T. POWELL, ROBERT T. SIHERWOOD

Research Assistant Professor: CHARLES S. HODGES, JR.

The Department of Plant Pathology offers graduate work leading to the Master of Science and Doctor of Philosophy degrees.

The department is equipped with laboratory and greenhouse facilities for graduate study in plant pathology including special equipment for all phases of phytopathological research. The State's wide range of soil types and climatic areas make possible the commercial production of a variety of field, vegetable, fruit, and ornamental crops. Especially favorable opportunities exist for training in diseases caused by nematodes, viruses, fungi, and bacteria which affect many crops. Land and facilities for experimental work are available at some sixteen permanent research stations located throughout the State. Student participation in the Plant Disease Clinic provides top-notch training and experience in the diagnosis of all types of plant diseases.

Many opportunities for employment in research, extension, and teaching are available to persons with the Master of Science or Doctor of Philosophy degree in plant pathology. There are openings for qualified persons in plant pathology research in the United States Department of Agriculture, State Experiment Stations and in industry. Opportunities exist in foreign service through international and federal organizations as well as commercial production enterprises. The rapid development of agricultural chemicals for disease control offer numerous opportunities in both research, promotion, and service activities.

Courses for Advanced Undergraduates and Graduates

PP 500. Advanced Plant Pathology

0-2

Prerequisites: PP 315 or equivalent

An advanced study of the economic importance, symptoms, disease cycles, epiphytology and control of major groups of plant diseases. Students who register for this course are also required to register for either PP 501 or PP 502, or they may register for both.

Mr. Winstead.

PP 501. Advanced Plant Pathology Laboratory-Field Crops Diseases

0-1

Prerequisite: PP 315 or equivalent.

Laboratory course for students whose major interest is diseases of field crops to accompany lecture course in Advanced Plant Pathology (PP 500). Diseases will be selected for study which are important on field crops. Either this course or PP 502 must be taken concurrently with PP 500.

Mr. Kline.

PP 502. Advanced Plant Pathology Laboratory-Horticultural Crop Diseases

0-1

Prerequisite: PP 315 or equivalent.

Laboratory course for students whose major interests is in diseases of horticultural crops to accompany lecture course in Advanced Plant Pathology (PP 500). Diseases will be selected for study which are important on fruit, ornamental and vegetable crops. Either this course or PP 501 must be taken concurrently with PP 500.

Mr. Winstead.

*****PP 503. Diagnosis of Plant Diseases**

Summer School 3

Prerequisites: One advanced course in Plant Pathology and permission of instructor

A study of techniques used in plant disease diagnosis with emphasis on diagnostic value of signs and symptoms for certain types of diseases. Consideration will be given to major sources of descriptive information on plant pathogens and the use of keys for the identification of fungi.

Mr. Hebert.

Courses for Graduates Only

- PP 601. Phytopathology I** **4-0**
 Prerequisites: PP 315 and permission of the instructor
 A study of the principles of phytopathological research. The course is designed to apply the classical scientific method to disease investigation. Exercises will include appraising disease problems, reviewing literature, laboratory and greenhouse experiments and the evaluation and presentation of data. Mr. Apple.
- PP 602. Phytopathology II** **0-4**
 Prerequisites: PP 315 and permission of the instructor
 The basic concepts of the etiology, pathology, epiphytology and control of plant diseases. Mr. Nusbaum.
- PP 604. Plant Parasitic Nematodes** **2-0**
 Prerequisite: PP 315
 A study of morphology, anatomy, physiology and taxonomy of plant parasitic nematodes. Methods of isolating nematodes from soil and plant parts and other laboratory techniques used in the study and identification of nematodes will be considered. Mrs. Triantaphyllou.
- **PP 605. Plant Virology** **3-0**
 Prerequisites: PP 315, GN 411, and a course in organic chemistry
 A study of plant viruses including effects on host plants, transmission, classification, methods of purification, determination of properties, chemical nature, structure and multiplication. Mr. Hebert.
- *PP 607 and GN 607. Genetics of Fungi** **3-0**
 Prerequisites: GN 512, or equivalent and permission of instructor
 Review of major contributions in fungus genetics with emphasis on principles and theories that have evolved in recent developments. Mr. Nelson.
- **PP 608. History of Phytopathology** **1-0**
 Prerequisites: PP 315 and permission of instructor
 Development of the science of phytopathology from its early beginnings to the early part of the 20th century. Mr. Ellis.
- PP 609. Current Phytopathological Research Under Field Conditions** **0-2**
 Prerequisite: Graduate standing
 Study of concepts involved, procedures used, and evaluation made in current phytopathological research by Plant Pathology staff. Visits to various Research Stations will be made by the class. Mr. Clayton.
- PP 611. Nematode Diseases of Plants** **0-3**
 Prerequisite: PP 604
 A study of plant diseases caused by nematodes. Special consideration will be given to host-parasite relationships, host ranges and life cycles of the more important economic species. Principles and methods of control will be considered. Mr. Sasser.
- *PP 612. Plant Pathogenesis** **3-0**
 Prerequisite: PP 500
 A study of interactions of pathogens and susceptible plants. The following major topics will be considered: hydrolytic enzymes, polysaccharides, and toxins in wilting phenomena; mode of action of toxins in altering plant metabolism; role of growth regulators in hypertrophic responses; alterations in respiration and other physiological processes during pathogenesis; and nature and biochemical basis for disease resistance. Mr. Kelman.

* Offered 1962-63 and in alternate years.

** Offered 1963-64 and in alternate years.

PP 615. Research in Plant Pathology**Credits by arrangement**

Prerequisites: Graduate standing and consent of instructor.

Original research in Plant Pathology.

Graduate Staff.

PP 625. Seminar in Plant Pathology**1-1**

Prerequisite: Consent of seminar chairman

Discussion of phytopathological topics selected and assigned by seminar chairman.

Mr. Nielsen.

UNC BOTANY 212, 211. Advanced Mycology**5-5**

Prerequisite: BO 42 or 101 (UNC) or equivalent

Phycomycetes, Ascomycetes, Basidiomycetes and Fungi Imperfecti. These courses are intended for students who plan to specialize in Mycology, Plant Pathology, and Biology. Classwork consists of lectures and student reports on literature. Laboratory work consists of the collection and identification of fungi and the study of their structure and development, and techniques for isolation and pure culture.

Two hours of lecture and four hours of laboratory each week. Mr. Couch.

DEPARTMENT OF POULTRY SCIENCE**Graduate Faculty***Professors:* HENRY WILBURN GARREN, *Head*, CLIFFORD WARREN BARBER,

FRANK RANKIN CRAIG, CHARLES HORACE HILL, JR., MORLEY RICHARD KARE

Associate Professors: WILLIAM LOWRY BLOW, JOSEPH WHEELER KELLY*Assistant Professor:* FREEMAN WALDO COOK

The Department of Poultry Science offers graduate work leading to the Master of Science degree in poultry science with major studies in genetics, nutrition, veterinary pathology, and physiology. Students expecting to begin graduate study must have the equivalent of an undergraduate major in poultry and a background in the biological sciences. Fundamental work in chemistry, biochemistry, physiology, bacteriology, statistics, and fields that relate directly to the major interest are required as a part of the program for the Master of Science degree.

Facilities for graduate study include a laboratory building which contains offices, library, bird rooms, and other equipment for comprehensive research studies. In addition to the laboratory building, chicken and turkey research plants are available for use. These plants, with three branch farms located in the western, Piedmont and eastern part of the State, provide a place for genetic and nutrition studies under field conditions.

To offer wider scope to the regular programs of work, cooperative projects are under way with the United States Department of Agriculture in genetics and pathology.

Many opportunities exist in educational and commercial fields for poultry majors with advanced degrees. The larger feed manufacturers, hatcherymen, and commercial poultrymen as well as educational institutions need men with advanced training. The supply of trained men is limited and starting salaries are adequate.

Courses for Advanced Undergraduates**PO 401. Poultry Diseases****0-4**

Prerequisites: Required of majors in Poultry Science. Elective for others with permission of the instructor

The prevention, control, and treatment of the diseases of poultry.

Mr. Barber.

PO 402. Commercial Poultry Enterprises

0-4

Prerequisites: Required of majors in Poultry Science. Elective for others with permission of the instructor.

Principles of incubation, hatchery management, development and organization of plans for the building, operation, and maintenance of a commercial poultry plant. Problem.

Mr. Brown.

PO 403. Poultry Seminar

1-1

Prerequisites: Required of majors in Poultry Science, senior year

Topics and problems relating to Poultry Science and Poultry Industry assigned for report and discussion.

Staff.

PO 520. Poultry Breeding

3-0

Prerequisites: GN 411. Required of majors in Poultry Science

Elective for others with permission of the instructor

Application of genetic principles to chickens and turkeys, considering physical traits and physiological characteristics—feather patterns, egg production, hatchability, growth, body conformation, and utility. Laboratory problems.

Mr. Martin.

PO 521. Poultry Nutrition

3-0

Prerequisites: CH 203, 451. Required of majors in Poultry Science; elective for others

Protein, vitamin, and mineral requirements for growth, egg production, and reproduction in the chicken and turkey. Methods of feeding and compounding poultry mashes. Laboratory exercises in the production of vitamin and mineral deficiencies.

Mr. Kelly.

PO 522. Endocrinology of the Fowl

0-3

Prerequisite: ZO 301 or equivalent

Study of the endocrine system with respect to its physiological importance to metabolism, growth, and reproduction. Mammalian examples as well as the fowl are used to illustrate basic concepts. Laboratory techniques and demonstrations.

Mr. Garren.

Courses for Graduates Only

PO 602. Advanced Poultry Nutrition

Semester by arrangement

Prerequisites: PO 521, CH 551 or equivalent

Research problem in poultry nutrition involving the design and carrying out of microbiological and chick experiments. Results from microbiological and chick assays are correlated.

Mr. Hill.

PO 611. Poultry Research

Credits by arrangement

Prerequisite: Graduate standing in Poultry Science

Critical study of some particular problem involving original investigation. A maximum of six credits is allowed toward the Master's degree.

Graduate Staff.

PO 613. Special Problems in Poultry Science

Maximum 6

Prerequisite: Graduate standing

Specific problems using advanced technology for theory exploration.

Graduate Staff.

DEPARTMENT OF PSYCHOLOGY

(See School of Education)

DEPARTMENT OF RURAL SOCIOLOGY**Graduate Faculty**

Professors: SELZ CABOT MAYO, *Head*, CHARLES HORACE HAMILTON

Associate Professor: GLENN C. McCANN

Assistant Professor: JAMES N. YOUNG

The Department of Rural Sociology offers the Master of Science and the Doctor of Philosophy degrees.

Graduate students studying for the Doctor of Philosophy degree usually take approximately one semester of course work in the Department of Sociology at the University of North Carolina at Chapel Hill. Students seeking the Master of Science degree may take courses at Chapel Hill. However, they will be able to complete their entire programs at State College.

The physical and educational resources of the Rural Sociology Department, available to graduate students, include a departmental library of bulletins, monographs, and other materials consisting of several thousand items, accumulated over a period of thirty years, and catalogued in indexed files. Laboratory equipment consists of calculating machines, drawing table and instruments, chart making materials, cameras, typewriters, and statistical aids. Also at the disposal of the graduate students are automobiles used for making field surveys and IBM tabulating equipment operated by the Department of Experimental Statistics.

The Department of Rural Sociology provides training in a number of social sciences, and prepares the graduate student for a variety of positions. Men and women with graduate degrees in rural sociology have opportunities for careers in college teaching, sociological research, social statistics, social work, administration of social organizations and governmental agencies, agricultural journalism, and in branches of the government's foreign service relating to agriculture and the under-developed areas of the world.

Institutions offering employment to graduates are Land-Grant colleges, agricultural experiment stations, and extension services; other colleges and universities; the United States Departments of Agriculture, State, and Health, Education and Welfare; state departments of health, education and welfare; farm journals and newspapers, and voluntary social agencies such as Red Cross, Community Chest, Boy Scouts, and National Tuberculosis Association.

Each year outstanding graduate students are awarded research or teaching assistantships, usually requiring the devotion of half of their time to a research project or teaching function as appropriate. Cooperative research work with various governmental agencies frequently provides opportunities for part-time employment for graduate students not on assistant status.

Courses for Advanced Undergraduates and Graduates**RS 511. Rural Population Problems****3-0**

Prerequisite: RS 301

A study of population growth, rates of change, and distribution. Considerable attention is given to the functional roles of population, i.e., age, sex, race, residence, occupation, marital status, and education. The dynamic aspects of population are stressed: fertility, mortality, and migration. Popu-

lation policy is analyzed in relation to national and international goals. A world view is stressed throughout. Mr. Mayo.

RS 513. Community Organization

3-0

Prerequisite: RS 301

Community organization is viewed as a process of bringing about desirable changes in community life. Community needs and resources available to meet these needs are studied. Democratic processes in community action and principles of community organization are stressed, along with techniques and procedures. The roles of leaders, both lay and professional, in community development are analyzed. Mr. Mayo.

UNC Philo. 107. Foundations of the Social Sciences

0-3

Prerequisites: Two courses in philosophy, psychology or sociology

An inquiry into the nature of social reality through an examination of the basic concepts of sociology, history, etc. Behavioral and subjective approaches are contrasted. Both methodological and more broadly philosophical problems are discussed. Mr. Natanson.

***UNC Anthro. 121. Culture and Personality**

0-3

A scientific analysis of the influence of cultural forms on the individual in our own and other societies, considered from the anthropological, psychological, and clinical points of view. Mr. Honigmann.

UNC Soc. 122. Cultural Anthropology

3-0

A systematic survey of the customs and modes of life of mankind based on scientific explanation of the ways of culture. Fee: \$1.00. Fall.

Mr. Johnson.

UNC Soc. 125. The Negro

0-3

A study of the Negro community and its institutions, status of the Negro in American society, problems of race relations, and the process of integration. Spring. Mr. Johnson.

****UNC Soc. 128. Folk Cultures in the Modern World**

0-3

The folk culture is viewed as a way of life which stands midway between that of the "primitive" tribal native and of the urbanized city dweller. Fee: \$1.00. Mr. Erasmus.

RS 534. (HI 534.) The Farmers' Movement

0-3

Prerequisite: 3 hours of Sociology

A history of agricultural organizations and movements in the United States and Canada principally since 1865, emphasizing the Grange, the Farmers' Alliance, the Populist revolt, the Farmers' Union, the Farm Bureau, the Equity societies, the Nonpartisan League, cooperative marketing, government programs, and present problems. Mr. Noblin.

UNC Soc. 152. History of Social Thought

3-0

Prerequisite: One course in one of the social sciences or philosophy

Emphasis on historic social ideas of Western culture considered against a background of general cultural analysis in terms of systematic theory. Mr. Vance.

UNC Soc. 153. Social Structure

3-0

Analysis of social structure and stratification in terms of class, status, prestige, rank, and function. Attention is given to the social role of the elite, bureaucracies, and professional and middle classes. Mr. Vance.

UNC Soc. 161. Sociology of the Family

0-3

Analysis of the family institution as a background for the study of family interaction: socialization and the parent-child relationship, courtship and marriage interaction, family crises and problems. Mr. Bowermann.

* Offered in the spring of 1961-62 and alternate years.

** Offered in 1961-62 and alternate years.

UNC Soc. 168. The City 0-3
The city as a social phenomenon in the modern world. Analysis of urban trends, characteristics, and functions; urban social organization. Sociological elements in housing, urban planning, and metropolitan dominance. Growth patterns in new centers of urbanization. Mr. Campbell.

UNC Soc. 181. Regional Sociology of the South 0-3
A sociological analysis of the southern region of the United States. Emphasis on fact, factors, and policies pertaining to geography, population and culture; resources and waste; social institutions and planning. Mr. Simpson.

Courses for Graduates Only

UNC Soc. 210. Folk Sociology 3-0
Folk sociology as a subject field for the historical study of total human society and the empirical study of group behavior. Mr. Simpson.

RS 611. Research Methods in Sociology 3-0
Prerequisite: 6 hours of Sociology
Designed to give the student a mature insight into the nature of scientific research in sociology. Assesses the nature and purpose of research designs, the interrelationship of theory and research, the use of selected techniques and their relation to research designs, and the use of modern tabulation equipment in research. Mr. McCann.

UNC Soc. 212. American Sociologists 0-3
A general treatise on the rise and development of American sociology and a survey of the work and personalities of American sociologists projected on the background of social theory and research. Mr. Simpson.

****UNC Soc. 218. Human Ecology (Seminar)** 0-3
Consideration of theory and research emerging around the concept of human ecology. A review of the background of human ecology is followed by readings, reports, and research on its contemporary development. Mr. Vance.

***UNC Anthro. 220. Theories of Culture** 0-3
A systematic survey of the history in cultural anthropology leading to the development of a system of operational principles which the student may apply in his own fieldwork and further studies involving cultural problems. Mr. Honigmann.

RS 621. Rural Social Psychology 3-0
Prerequisite: 6 hours of Sociology
Treats the genetic development of the rural personality and the interrelationship of the individual and the rural society. Studies of social psychological factors related to rural leadership, morale, social organization, and social change, and examines the attitudes and opinions of rural people on current local and national issues. Mr. McCann.

UNC Anthro. 221. Field Methods in Cultural Anthropology 0-3
Practical exercises and discussion cover topics of role taking, observation, interviewing, note taking, and pattern generalization. Mr. Honigmann.

UNC Anthro. 230. Race and Culture Contacts 0-3
An analysis of acculturation situations arising from contacts of peoples of different racial or cultural heritages in America, Africa, Polynesia, Melanesia, and other areas. Mr. Johnson.

* Offered in 1961-62 and alternate years.

** Offered in 1962-63 and alternate years.

RS 631. Population Analysis**0-3**

Prerequisite: 6 hours of Sociology

Methods of describing, analyzing, and presenting data on human populations: distribution, characteristics, natural increase, migration, and trends in relation to resources.

Mr. Hamilton.

RS 632. Rural Family**3-0**

Prerequisite: 6 hours of Sociology

Emphasis is placed on the development of an adequate sociological frame of reference for family analysis; on discovering both the uniquely-cultural and common-human aspects of the family by means of cross-cultural comparisons; on historical explanations for variability in American families with especial concern for the rural family; and on analyzing patterns of family stability and effectiveness.

Mr. Hamilton.

RS 633. The Rural Community**0-3**

Prerequisite: 6 hours of Sociology

The rural community is viewed in sociological perspective as a functioning entity. A method of analysis is presented and applied to eight "dimensions," with emphasis on the unique types of understanding to be derived from measuring each dimension. Finally, the effect of change on community integration and development is analyzed.

Mr. Mayo.

UNC Soc. 262. European Sociological Theory**3-0**

Theory in sociological research. Major methodological and theoretical orientations. Development from European backgrounds of current theories of differentiation, integration, change, social systems and structural-functional analysis.

Mr. Simpson.

UNC Soc. 333. Seminar in Marriage and the Family**3-0**

Mr. Bowerman.

****UNC Soc. 334. Critique of Research in Marriage and the Family****3-0**

This seminar reviews the basic conceptual frameworks used in family research in the past; identifies changing emphasis in family study; and evaluates current studies in the major fields of family research.

Mr. Bowerman.

UNC Psych. 233. Methods of Investigation in Social Psychology**0-3**

Methods of investigation in social psychology with application to the social sciences. Survey methodology with particular emphasis on techniques, contributions, and limitations of public opinion polling.

Mr. Thibaut.

RS 641. (ST 641) Statistics in Sociology**3-0**

Prerequisite: Statistics 513

The application of statistical methods of sociological research. Emphasis on selecting appropriate models, instruments, and techniques for the more frequently encountered problems and forms of data.

Mr. Hamilton.

RS 642. Research in Rural Sociology**Credits by arrangement**

Prerequisite: Permission of chairman of graduate study committee. (Maximum of six credits.)

Planning and execution of research, and preparation of manuscript under supervision of graduate committee.

Staff.

RS 653. Theory and Development of Rural Sociology**0-3**

Prerequisite: 6 hours of Sociology

Required of all masters and doctoral candidates in rural sociology and is recommended for all graduate minors. Designed to meet two objectives: (1) to introduce the student to the study of current sociological theory, and (2) to survey events and trends in the historical development of rural sociology.

Mr. Hamilton.

** Offered in 1962-63 and alternate years.

UNC Religion 170. Sociology of Religion**0-3**

Analysis of tensions between the scientific, ethical, and theological study of society; the role of religion in social change; the social origins of the denominations; the sociological significance of the Reformation; "sect" and "church" in sociological theory.

Mr. Nash.

RS 671. Seminar**Credits by arrangement**

Appraisal of current literature; presentation of research papers by students; progress reports on departmental research; review of developing research methods and plans; reports from scientific meetings and conferences; other professional matters. (A maximum of three credits is allowed toward the master's degree, and six credits toward the doctorate.)

Staff.

DEPARTMENT OF SOCIOLOGY AND ANTHROPOLOGY**Graduate Faculty**

Professor: SANFORD RICHARD WINSTON, *Head*

Associate Professors: ELMER HUBERT JOHNSON, HORACE D. RAWLS

Assistant Professor: JOHN W. TOMLIN

The Department of Sociology and Anthropology does not offer graduate degrees. However, the department supplies courses that are acceptable for graduate credit as part of a program in other areas of graduate study.

Courses for Advanced Undergraduates**SOC 401. Human Relations in Industrial Society****3 or 3**

Prerequisite: Senior status or permission of instructor

Selected societies about the world are contrasted with American society to demonstrate the correlation between technology and general behavior patterns, both within industry and in the total social order. The patterns of adjustment by the individual to the organizational framework (business concern, manufacturing enterprise, etc.) are analyzed in terms of social status, social roles, work norms, and attitudes. The social significance of major characteristics of contemporary industry is considered in terms of such topics as enlargement of the geographic bounds of the human community, development of occupational specialization, alteration of the character of inter-group interaction, and the growing integration of American culture. The interrelationships between industry and social change are discussed to show the effect of new social conditions upon industrial operations and the effect of technological change upon the family, school, church, and government. The contribution of industry to social progress is analyzed to promote the student's understanding of the dynamic quality of the social environment within which he will function.

SOC 402. Urban Sociology**3 or 3**

Prerequisites: SOC 202 and permission of instructor

The course begins with a study of the factors behind the organic growth of cities. The relationship between the physical design of cities and their social organization is discussed. This is followed by a detailed analysis of new developments in the serving of human needs (adequate housing, and the design of physical and social structures for religious, educational, public welfare, and recreational activities). Socio-psychological aspects of life in an urbanized society are compared with those of predominantly agricultural societies. The increasing integration of urban and rural living is emphasized.

Finally, the changing character of urban life is seen in the resulting demand for city and regional planning and the use of administrative personnel having both technical and social backgrounds.

SOC 411. Community Relationships

3 or 3

Prerequisites: SOC 202 and permission of instructor

A survey of the institutions, organizations, and agencies to be found in modern communities; the social conditions or problems, such as recreation, health, welfare, etc., with which they deal; their inter-relationship and the trend toward over-all planning.

SOC 412. Introduction to Social Work

3 or 3

Prerequisites: SOC 202 and permission of instructor

An introductory course, designed to acquaint students with the various types of public and private social work and with remedial and preventive programs in applied sociology, social psychiatry, health, public welfare, and recreation.

SOC 414. Social Structure

3 or 3

Prerequisites: Six hours in Sociology and permission of instructor

Studies of the major social institutions and systems of stratification; the organization of social systems as, for example, religion, education, and government; the functions of such structural components as age and sex groups, vocational and professional groups, and social classes.

Messrs. Winston, Johnson.

SOC 416. Research Methods

3 or 3

Prerequisites: Nine hours in Sociology and permission of instructor

An analysis of the principle methods of social research; the development of experiments; schedules and questionnaires; the measurement of behavior.

Messrs. Winston, Johnson.

Courses for Graduates and Advanced Undergraduates

SOC 501. Leadership

3 or 3

Prerequisites: SOC 202, SOC 301, or equivalent

A study of leadership in various fields of American life: analysis of the various factors associated with leadership; techniques of leadership. Particular attention is given to recreational, scientific, and executive leadership procedures.

Mr. Winston.

SOC 502. Society, Culture, and Personality

3 or 3

Prerequisites: SOC 202, SOC 301, or equivalent

Human personality is studied from its origins in primary groups through its development in secondary contacts and its ultimate integration with social norms. While comparative anthropological materials will be drawn upon, emphasis is placed upon the normal personality and the adjustment of the individual to our society and to our culture. The dynamics of personality and character structure are analyzed in terms of the general culture patterns and social institutions of society.

Messrs. Rawls, Winston.

SOC 505. The Sociology of Rehabilitation

3 or 3

Prerequisites: SOC 202, SOC 301, or equivalent

The course stresses the social and cultural implications of the rehabilitation approach. Emphasis is placed upon the social and personal problems of physically and mentally handicapped persons. The interrelationships of the major social environments are considered at length in this regard. Objectives of the rehabilitation processes are analyzed in terms of the sociology of work. A major portion of the course is devoted to rehabilitation as a profession, particular attention being given to the diverse roles of specialists in this field.

Mr. Rawls.

SOC 510. Industrial Sociology**3 or 3**

Prerequisites: SOC 202, SOC 301 or equivalent

Industrial relations are analyzed as group behavior with a complex and dynamic network of rights, obligations, sentiments, and rules. This social system is viewed as an interdependent part of total community life. The background and functioning of industrialism are studied as social and cultural phenomena. Specific social problems of industry are analyzed.

Mr. Johnson.

SOC. 511. Social Theory**3 or 3**

Prerequisites: Nine semester hours of sociology, or equivalent work in related fields, and permission of instructor.

The study of social theories from the earliest recorded thinkers to those of modern times; the evolution of theories of the individual, groups, culture, community, and society; the modern development of sociology and anthropology, and interpretive systems accompanying these developments.

Graduate Staff.

SOC 515. Research in Applied Sociology**3-3**

Prerequisites: SOC 202, SOC 301, or equivalent

Individual research problems in applied fields of sociology, such as problems of the family, population, and social work; rural-urban relations; student success; American leadership.

Graduate Staff.

DEPARTMENT OF SOIL SCIENCE**Graduate Faculty**

Professors: JAMES WALTER FITTS, *Head*, WILLIAM VICTOR BARTHOLOMEW, JAMES FULTON LUTZ, WILLIAM GARLAND WOLTZ, WILLIAM WALTON WOODHOUSE, JR.

Associate Professors: WILLIAM A. JACKSON, EUGENE J. KAMPRATH, CHARLES B. McCANTS, RALPH JOSEPH McCracken, PRESTON HARDING REID, JAMES M. SPAIN, RICHARD J. VOLK, STERLING B. WEED, SANFORD EUGENE YOUNTS

Assistant Professors: GEORGE A. CUMMINGS, ROBERT E. MCCOLLUM

The Department of Soil Science offers training leading to the degrees of Master of Science and Doctor of Philosophy with major emphases in the fields of soil chemistry, soil fertility, soil physics, soil genesis, and soil microbiology.

Facilities are provided for soils graduate teaching and research in Williams Hall, a large modern building. Office and laboratory space is assigned to each student. A library equipped with books, periodicals and biographic material relative to soils and related subjects is maintained for departmental use. Facilities set up for graduate study include radioactive and stable isotope laboratories containing automatic recording scalers, a mass spectrometer, and other modern equipment. Complete equipment for soil mineralogical studies include x-ray diffraction apparatus with fluorescence, differential thermal analyses, infrared spectrophotometer, polarizing microscope, high speed centrifuges and thin sectioning apparatus. Photomicrographic equipment is available for photographing thin sections and microorganisms.

Service laboratories for routine soil and plant analyses are available as well as special preparation rooms for soil and plant samples. Greenhouses and growth chambers situated at the back of Williams Hall are accessible

for controlled plant studies. Outdoor experiments in concrete frames, large tile, or small plots are conducted in an area near Williams Hall. Field experiments are made on the sixteen research farms owned or operated by the State. These farms are located throughout North Carolina to include a wide variety of soil and climatic conditions needed for experiments in soils. One of the largest and best equipped soil testing laboratories in the United States is operated by the North Carolina Department of Agriculture in Raleigh. Special studies on the various problems of soil testing can be made in conjunction with this laboratory.

Strong supporting departments greatly increase the graduate student's opportunities for a broad and thorough training. Included among those departments in which graduate students in soil science work cooperatively or obtain instructions are crop science, botany, chemistry, geology, mathematics, plant pathology, physics, and statistics.

Courses for Graduates and Advanced Undergraduates

SSC 511. Soil Physics

4-0

Prerequisites: SSC 200 and PY 212

Physical constitution and analyses; soil structure, soil water, soil air and soil temperature in relation to plant growth.

Mr. Lutz.

****SSC 522. Soil Chemistry**

0-4

Prerequisites: SSC 200, SSC 553 and CH 433 or permission of instructor

A consideration of the chemical and colloidal properties of clay and soil systems, including ion exchange and retention, soil solution reactions, solvation of clays, and electrokinetic properties of clay-water systems.

Mr. Weed.

***SSC 524. Mass Spectrometry**

0-2

Prerequisites: SSC 302 and CH 433 or permission of instructor

An examination of theoretical and analytical aspects of mass spectrometry and stable isotopic techniques; application of these methods to biochemical research.

Mr. Volk.

***SSC 532. (BO 532) Soil Microbiology**

0-3

Prerequisites: SSC 302, BO 312 and CH 220

The more important microbiological processes that occur in soils; decomposition of organic materials, ammonification, nitrification, and nitrogen fixation.

Mr. Bartholomew.

SSC 541. Soil Fertility

3-0

Prerequisites: SSC 302 and SSC 341

Soil conditions affecting plant growth and the chemistry of soil and fertilizer interrelationships. Factors affecting the availability of nutrients. Methods of measuring nutrient availability.

Mr. Kamprath.

***SSC 551. Soil Morphology, Genesis and Classification**

3-0

Prerequisites: SSC 200, SSC 302 or 341 and MIG 120

Morphology: Study of concepts of soil horizons and soil profiles and chemical, physical and mineralogical parameters useful in characterizing them. Genesis: Critical study of soil forming factors and processes. Classification: Critical evaluation of historical development and present concepts of soil taxonomy with particular reference to great soil groups as well as discussion of logical basis of soil classification.

Mr. McCracken.

SSC 553. Soil Mineralogy

3-0

Prerequisites: SSC 200, SSC 341 and MIG 330 or permission of instructor

* Offered in 1962-63 and alternate years.

** Offered in 1963-64 and alternate years.

Composition, structure, classification, identification, origin, occurrence, and significance of soil minerals with emphasis on primary weatherable silicates, layer silicate clays, and sesquioxides. Messrs. McCracken and Weed.

*****SSC 560. North Carolina Soils and Their Management 3(Summer)**

Prerequisites: SSC 200, SSC 302 or SSC 341

Field studies of selected soil series in the Coastal Plain, Piedmont and Mountain areas of North Carolina. Discussion of management practices that should be associated with the various soils under different types of farming. Messrs. McCracken, Fitts, and Spain.

SSC 570. Special Problems

Credits by arrangement

Prerequisites: SSC 200 and SSC 302

Special problems in various phases of soils. Problems may be selected or will be assigned. Emphasis will be placed on review of recent and current research. Staff.

Courses for Graduate Students Only

***SSC 622. Physical and Chemical Properties of Soils**

0-4

Prerequisites: SSC 511, SSC 522, CH 433, MA 301 or permission of instructor

An examination in depth of current ideas concerning the physics and chemistry of soil and clay systems. Topics will include ion exchange, molecular adsorption, electrokinetics, relations between mineral structures and their physical and chemical properties, and the properties of adsorbed water. Emphasis will be determined by student interest and by current literature.

Messrs. Miller and Weed.

****SSC 651. Pedology**

2 or 3-0 (By arrangement)

Prerequisites: SSC 522 and SSC 511

A critical study of current theories and concepts in soil genesis and Morphology; detailed study of soil taxonomy. Topics include weathering and clay mineral genesis as related to soil morphology and genesis, functional analyses of soil genesis, properties of and processes responsible for soil profiles formed under various sets of soil forming factors, classification theory and logic as applied to soil classification, structure of soil classification schemes. Any of those topics may be emphasized at the expense of the others according to interests of students. Mr. McCracken.

****SSC 672. Soil Properties and Plant Development**

0-4

Prerequisites: CH 551, SSC 522 or equivalents

A detailed examination of the effects of soil factors in the development of crop plants. Segments of the course will treat (1) soil transformation processes of both organic and inorganic constituents, (2) concepts of nutrient availability and (3) the relation of plant development indices to specific soil properties. Messrs. Jackson, Bartholomew and Davey.

SSC 680. Seminar

1-1

Prerequisite: Graduate standing in Soil Science

Scientific articles, progress reports in research and special problems of interest to agronomists reviewed and discussed.

A maximum of two credits is allowed toward the Master's degree, but any number toward the Doctorate. Graduate Staff.

SSC 690. Research

Credits by arrangement

Prerequisite: Graduate standing in Soil Science

A maximum of six credits is allowed toward the Master's degree, but any number toward the Doctorate. Graduate Staff.

* Offered in 1962-63 and alternate years.

** Offered in 1963-64 and alternate years.

*** Offered in summer 1963 and alternate years.

SCHOOL OF TEXTILES

Graduate Faculty

Professors: MALCOLM EUGENE CAMPBELL, *Dean*, CLARENCE MONROE ASBILL, JR., JOHN FRANCIS BOGDAN, KENNETH STODDARD CAMPBELL, ELLIOT BROWN GROVER, DAME SCOTT HAMBY, HARLEY YOUNG JENNINGS, HENRY AMES RUTHERFORD, WILLIAM EDWARD SHINN

Associate Professors: ARTHUR A. ARMSTRONG, JR., DAVID MARSHALL CATES, ARTHUR COURTNEY HAYES, JOSEPH ALEXANDER PORTER, JR., WILLIAM CLIFTON STUCKEY, JR.

Assistant Professor: ERNEST BEZOLD BERRY

The School of Textiles offers programs leading to the Master of Science in textile technology and Master of Science in textile chemistry.

The fundamental objectives of the graduate program in the School of Textiles are to develop in students their abilities to initiate and conduct independent investigations which lead to the development of new knowledge, and to stimulate the thought processes associated with learning and decision making. These objectives are accomplished through programs designed to increase the general knowledge of the student and to develop a more comprehensive understanding of the major field through study and research.

The program of study for the graduate student in textile technology may be arranged in a way that a broad background in advanced technology will be developed and, at the same time, emphasize areas such as fiber and yarn technology, fabric technology, knitting technology, or quality control. In addition to the major field of textile technology, students may minor in fields such as experimental statistics, economics, mathematics, physics, engineering, psychology, and political science.

In the Department of Textile Technology the current activities in research include such problems as fundamental studies of man-made fiber properties, characterization of combed and carded yarns, influence of variation in linear density of in-process materials as related to finished product quality, and processing problems as associated with the newest developments in materials and supplementary equipment.

In the Department of Textile Chemistry research emphasis is placed on absorption studies, textile chemical processes, new materials and new methods, and modification of fibrous polymers. The objective of the graduate program is to stimulate basic research and to train scientists at the graduate level in the general field of fiber chemistry. Strong supporting programs are maintained in chemistry, chemical engineering, mathematics, experimental statistics, and physics. The Department of Textile Chemistry is presently located in the Nelson Textile Building, but will move its facilities, except for the Radiological Laboratory, to Mangum Hall which will house the chemical and physical testing laboratories and the processing laboratory comprising a bleaching, dyeing, and finishing pilot plant.

The physical resources of the School of Textiles are at the disposal of all graduate students. Separate research laboratories for both physical and chemical investigations are available for graduate research. The extensive research and educational programs of the school have facilitated the de-

velopment of a competent staff of instructors and researchers. A large, well-equipped shop is available in Nelson Textile Building for construction and maintenance of apparatus.

The Textile Library, a division of the College Library located in the Nelson Textile Building, is one of the largest and most complete of its type in the country, and offers facilities for graduate study.

A number of teaching assistantships and research fellowships are available. The stipend ranges from \$1,800 to \$2,400, with some fellowships also including tuition and fees.

The demand by industry and educational institutions for graduates with advanced degrees has constantly exceeded the supply. The financial remuneration is not only larger, but the professional development and recognition are generally more readily attained.

Courses for Advanced Undergraduates

Textile Technology

TX 430. Continuous Filament Yarns

3-3

Prerequisite: TX 303

Required of students in Fiber and Yarn Technology and Knitting Technology

Elective for others

A study of properties and processes applicable only to filament yarns such as texturizing and bulking. Detailed studies of throwing systems, engineering requirements of equipment, and yarn property changes resulting from processing.

Two 1-hour lectures and one 2-hour laboratory period per week.

Mr. Wiggins.

TX 436. Staple Fiber Processing

3-3

Prerequisite: TX 303

Required of students in Fiber and Yarn Technology

Elective for others

A study of special systems of processing long staple, natural and man-made fibers, including woolen, worsted, direct spinning, Turbo Stapler, or Pacific Converter, and sliver to yarn methods. New concepts and research findings as applied to all yarn processes.

Two 1-hour lectures and one 2-hour laboratory period per week.

Mr. Pardue.

Textile Chemistry

TC 403, 404. Textile Chemical Technology

5-5

Prerequisites: TC 304; CH 223

Required of seniors in Textile Chemistry

Basic principles are applied to the study of three important areas of textile processing: dyeing, printing, and finishing. These areas are concerned with the chemical nature of dyes and other chemical agents applied to fibrous systems; with the chemical and physical properties of the various fibers; and with the mechanical aspects of the application of chemical materials to fibers and fabrics. The course includes an extensive review of the various classes of dyes and their application to all important textile fibers and blends of fibers; a comparative analysis of dyeing machinery and processes involving special machinery and equipment; a survey of modern preparatory

and bleaching for all important fibers; a study of the roller printing machine, and the principles involved in print formulations for the major classes of dyes and their application to the various fibers; a study of important mechanical, additive, and chemical modification type finishes for fabric. Three 1-hour lectures and two 3-hour laboratories per week.

Mr. Campbell.

TC 412. Textile Chemical Analysis II

Prerequisites: CH 215 and TC 304

Required of students in Textile Chemistry

Analysis of textile materials involving specialized instruments, and techniques such as spectrophotometry, pH measurements, electrometric titration, viscometry, etc. One 1-hour lecture and two 3-hour laboratories per week.

Messrs. Campbell, Cates, Rutherford.

3-0

TC 421. Fabric Finishing I

Prerequisite: TC 201

Students in Textile Chemistry may not take this course for degree credit. A general course in fabric finishing designed for students not majoring in Textile Chemistry. Emphasis placed on finishes used on garment-type fabrics, including stabilization finishes, water repellency, crease resistance, moth and mildew proofing, fire-proofing, etc. Emphasis on chemistry of finishes varied to fit requirements of students. Two 1 hour lectures per week.

Mr. Hayes.

0-2

General Textile Courses

TX 483. Textile Cost Methods

Prerequisites: TX 303 and TX 365

Required of seniors in Textiles except those in Management Option

A survey of cost methods applicable to textile mills with emphasis on calculations, the preparation of cost reports, and their use in cost control.

Two 1-hour lectures per week.

Mr. Shinn.

2-2

Knitting Technology

TX 441. Flat Knitting

Prerequisite TX 342

Required of seniors in Knitting Technology

Elective for others

A study of the leading types of flat knitting machines including warp knitting machines, design possibilities and fabric adaptability. Two 1-hour lectures and one 2-hour laboratory per week.

Mr. Shinn.

3-0

TX 442. Knitted Fabrics

Prerequisite TX 342

Required of seniors in Textile Technology and Knitting Technology

Design, analysis, and production of knitted fabrics, including flat, circular, and warp types. The economic aspects of the knitting process as a method of clothing production. Introduction to garment design, production and marketing. Two 1-hour lectures and one 2-hour laboratory period per week.

Messrs. Shinn, Middleton.

3-3

TX 444. Garment Manufacture

Prerequisite: TX 342

Required of seniors in Knitting Technology

Elective for others

A study of circular latch needle and spring needle machines for knitted fabric production. Styling, cutting and seaming of the basic garment types

0-3

for underwear and outerwear, standard seam types; high-speed sewing machines. Two 1-hour lectures and one 2-hour laboratory period per week.

Mr. Shinn.

TX 445. Full-Fashioned Hosiery Manufacture

0-2

Prerequisite: TX 342

Offered by election

Mechanics of the full-fashioned hosiery machine including practical training in its adjustment and operation. Attention is given to yarn preparation, knitting, inspection, finishing and packaging hosiery. Two 1-hour lectures per week.

Mr. Lewis.

TX 447, 448. Advanced Knitting Laboratory

2-2

Prerequisite: TX 342

Required of seniors in Knitting Technology

Elective for others

Systematic study of circular hosiery mechanisms; hosiery types and constructions. Seamless hosiery production methods utilizing the newer synthetic yarns, toe closing methods, finishing processes, and marketing are emphasized.

Mr. Lewis.

TX 449. Tricot Knitting

0-3

Prerequisite: TX 342

Elective for juniors and seniors

A study of basic types of tricot knitting machines with emphasis on mechanisms and fabrics. Attention is given to warp preparation methods applicable to the tricot machine, the characteristics of yarn made from natural and synthetic fibers as they affect processing into warp knitted fabrics, machine settings for proper qualities and ratios; economics of warp knitting, and end uses. Attention is given to fabric design and analysis. Two 1-hour lectures and one 2-hour laboratory period per week.

Mr. Shinn.

TX 478. Design and Weaving

3-3

Prerequisite: TX 366

Required of students in Fabric Technology

Elective for others

Advanced study of special weave formations and the techniques and equipment necessary to form these fabrics. Studies in depth of new developments and research findings in the areas of warp preparation, design, weaving and fabric formation. Two 1-hour lectures and one 2-hour laboratory period per week.

Messrs. Porter, Berry.

TX 485. Mill Design and Organization

0-3

Prerequisites: TX 303; TX 365

Required of students in the Textile Technology curriculum. For seniors in final semester only. (Effective—Fall, 1963)

Application of economic principles to textile factoring, hedging, and other buying and selling problems. Inventory control, organization, and departmental functions of textile companies. Technical problems of plant site selection, plant design and layout, and selection of equipment. Layout of a mill by each student. Two 1-hour lectures and one 2-hour laboratory period per week.

Messrs. Grover, Pardue.

TX 490. Development Project I

1-1

Prerequisite: Senior standing and permission of instructor

Elective

A problem of independent study assigned to seniors in the major field of study serving also as the laboratory period for senior level courses. One 2-hour laboratory period per week.

Courses for Graduates and Advanced Undergraduates

Textile Technology

TX 501. Textile Technology Seminar
2-2

Prerequisite: Senior standing and permission of instructor

Elective

Lecture and discussion periods are designed for students who are particularly interested in the yarn manufacturing aspects of the textile industry. Subject matter will include such various aspects as training methods, safety programs, modern mill design, specialized techniques in setting rates, employee relations, and developments that arise from technical meetings.

Two 1-hour lectures per week.

Mr. Grover and Graduate Staff.

TX 521. Textile Testing II
3-0

Prerequisite: TX 327

Elective

Advanced techniques for measuring properties of natural and man-made fibers, yarns, and fabrics. Interrelations of raw material, quality, processing characteristics, and end product properties. The application of the laws of physical sciences to evaluation of textile materials.

Two 1-hour lectures and one 3-hour laboratory per week.

Messrs. Hamby, Stuckey.

TX 522. Textile Quality Control
0-3

Prerequisite: TX 521

Elective

Quality control systems for textile operations. Defect prevention methods, isolation of processes contributing to substandard quality, relationship between quality control department and operating division. Laboratory design, equipment and personnel selection, installation of quality control systems. Two 1-hour lectures and one 3-hour laboratory period per week.

Messrs. Hamby, Stuckey.

TX 524. Special Projects in Textiles
1 to 3

Prerequisite: TX 327; Senior standing, permission of instructors

Elective

Special studies in either the major or minor field of the advanced undergraduate or graduate student. These special studies will take the form of current problems of the industry, independent investigations in the areas of textile testing and quality control, seminars and technical presentations, both oral and written.

Staff.

TX 525. Advanced Textile Microscopy
2-2

Prerequisite: TX 327

Elective

Experiments, lectures and demonstrations in more advanced techniques of textile microscopy. Detailed studies of structures of fibers covered in lecture series, supplemented by experiments on lecture topics. Detailed study of all types of microscopes and their uses in textiles. Preparation of slides for photography. Uses of photomicrographic equipment.

Lectures and laboratories arranged.

Mr. Stuckey.

TX 551. Complex Woven Structures
4-4

Prerequisites: TX 303 and TX 478

Elective

The development of design specifications for complex fabrics as related to fabric geometry, functional and aesthetic properties and manufacturing limitations. Three 1-hour lectures and one 2-hour laboratory per week.

Mr. Berry.

TX 575. Fabric Analytics and Characteristics**3-3**

Prerequisites: TX 365 or TX 366 or TC 511

Analysis and study of textile fabrics to determine the composite effects of yarn and fiber properties. Fabric design features that are related to mechanical as well as aesthetic properties. Engineering of fabrics based on utilization of other mixtures and homogeneous blends of natural and man-made fibers. Three 1-hour lectures per week.

Mr. Porter.

Textile Chemistry**TC 501. Seminar in Textile Chemistry****0-2**

Prerequisite: TC 403

Required of seniors in Textile Chemistry

The course is designed to familiarize the student with the principal sources of textile chemical literature and to emphasize the importance of keeping abreast of developments in the field of textile chemistry. Particular attention is paid to the fundamentals of technical writing. Reports.

Lectures arranged.

Mr. Campbell, Staff.

TC 511. Chemistry of Fibers**3-0**

Prerequisite: CH 223

Required of seniors in Textile Chemistry

A lecture course emphasizing the theory of fiber structure; the relationship between the chemical structure and physical properties of natural and man-made fibers; the nature of the chemical reactions which produce degradation of fibers; the production of man-made fibers.

Three 1-hour lectures per week.

Mr. Rutherford.

TC 512. (CH 512) Chemistry of High Polymers**0-3**

Prerequisite: CH 431

Elective.

Principles of condensation and free radical polymerization; kinetics and molecular weight description; copolymerization and composition; emulsion polymerization; structure. Three 1-hour lectures per week.

Mr. Cates.

TC 521. Textile Chemical Analysis III**3-3**

Prerequisite: TC 421 or permission of instructor

Elective for students in Textile Technology

No credit allowed for students majoring in Textile Chemistry

The work includes a survey of organic chemistry, with emphasis on organic surfactants, warp sizes, and fabric finishes of all types; the identification of fibers by chemical means; the qualitative and quantitative analysis of fiber blends by chemical means; the identification of finishes; the evaluation techniques for dyed and finished materials. Two 1-hour lectures and one 3-hour laboratory period per week.

Staff.

General Textiles**TX 581. Instrumentation and Control****3-3**

Prerequisite: PY 212

Required of all seniors in Textiles and Textile Chemistry

A lecture series with coordinated laboratory exercises designed to familiarize the student with the theory and application of instruments and control apparatus that he will find in the modern textile plant.

The studies cover the measurement and control of temperature, humidity, pressure, flow and liquid level, the application of control apparatus to chemical processes and physical finishing of textile products.

Two 1-hour lectures and one 2-hour laboratory period per week.

Mr. Asbill.

Courses for Graduates Only**TX 601, 602. Yarn Technology****3-3**

Prerequisite: Graduate Standing

Studies of advanced techniques in textile production; the technological aspects of fiber properties in relation to processing; studies of research findings and application of these to processing equipment.

Messrs. Grover, Hamby.

TC 606. Chemistry of Fiber-Forming High Polymers**3-0**

Prerequisite: CH 431

Structure and properties of fibers; thermodynamics of sorption and solution; solution properties; molecular weight determination; flow properties; mechanical properties. Three 1-hour lectures per week.

Mr. Cates.

TX 621. Textile Testing III**2-2**

Prerequisite: TX 522 or equivalent

Design of textile laboratories, including conditioning equipment and instruments required for specific needs; performance of tests and analysis of data on industrial problems; specialized physical tests; inter-laboratory tests and analysis; study of A. S. T. M. specifications and work on task groups for the A. S. T. M. Society.

Mr. Hamby.

TX 631. Synthetic Fibers**0-2**

Prerequisites: TX 430 or TX 436, or equivalent

Lectures and projects on advanced problems relative to the properties and processing of man-made continuous filament and staple fiber yarns.

Messrs. Grover, Hamby.

TX 641, 642. Advanced Knitting Systems and Mechanisms**3-3**

Prerequisite: TX 441 or equivalent

A critical study of inventions which have contributed to the development of the modern knitting industry; knitting needles and their adaption for specific uses; means for mounting them for individual and en masse operation; construction and functioning of cooperating elements including sliders, jacks, sinkers, dividers, pressing elements, narrowing and tensioning and draw-off motions, regulating mechanisms, timing and control chains and cams. Use will be made of patent literature which covers important developments in the hosiery industry. Three 1-hour lectures per week.

Mr. Shinn.

TX 643, 644. Knitting Technology**3-3**

Prerequisites: Graduate standing and 8 credits in Knitting Technology

Problems of specific interest to the knitting industry will be assigned for study and investigation. The use of experimental methods will be emphasized. Attention will be given to the preparation of reports for publication.

Graduate Staff.

TX 651, 652. Fabric Development and Construction**3-3**

Prerequisite: Graduate Standing

Application of advanced technology to the development and construction of woven fabrics.

Mr. Porter.

TX 681. Textile Research**Credits by Arrangement**

Problems of specific interest to the textile industry will be assigned for study and investigation. The use of experimental methods will be emphasized. Attention will be given to the preparation of reports for publication. The master's thesis may be based upon the data obtained.

Graduate Staff.

TX 683. Seminar**1-1**

Discussion of scientific articles of interest to textile industry; review and discussion of student papers and research problems.

Graduate Staff.

TC 605. Physical Chemistry of Dyeing**3-3**

Prerequisite: CH 433

Development of principles of thermodynamics, emphasizing applications in dye and fiber chemistry. Mr. Cates.

TC 606. Chemistry of Fiber-Forming High Polymers**3-3**

Prerequisite: CH 431

Composition and structure of high polymers; properties of linear polymers with particular emphasis on mechanical behavior; chemistry of high polymer degradation. Three 1-hour lectures per week. Mr. Cates.

DEPARTMENT OF ZOOLOGY**Graduate Faculty**

Professors: FREDERICK SCHENCK BARKALOW, JR., *Head*, DANIEL SWARTWOOD GROSCH, REINARD HARKEMA, MORLEY RICHARD KARE, THOMAS LAVELLE QUAY

Professor Emeritus: BARTHOLOMEW BRANDER BRANDT

Associate Professors: WILLIAM WALTON HASSLER, JOHN A. SANTOLUCITO

Assistant Professors: CHARLES WALTER ALLISTON, FRANCIS EUGENE HESTER, GROVER CLEVELAND MILLER

The Department of Zoology offers graduate work leading to the Master of Science and the Doctor of Philosophy degrees in animal ecology and wild-life biology. Graduate programs leading to advanced degrees in animal parasitology and other fields of zoology are arranged in cooperation with the Department of Zoology of the University of North Carolina, Chapel Hill.

The O. Max Gardner Biological Laboratories building houses training and research facilities. Also, offices and a number of research laboratories are set up for graduate student use. Library facilities are provided for advanced study in the areas of zoology in which graduate degrees are offered.

Collections of fish, reptiles, and amphibians used for teaching purposes are housed in the Zoology Department. In addition, a bird and mammal range which contains about 5,000 specimens and a wildlife teaching laboratory are set up in the department. Collections used for food habits research studies on native game animals are also found in the department.

Facilities for life history and ecologic studies in the field of animal parasitology are available for student use. A large autopsy and specimen preparation laboratory is housed in a building adjacent to the department headquarters in Gardner Hall. Also found in this building are an aquarium room, small mammal room, and demestid room.

A number of farm ponds ranging in size from two to seven acres are located on State land near Raleigh, and are available for research studies. Several experimental nursery pools are located adjacent to Gardner Hall, and additional facilities near Fayetteville have been made available through a cooperative program with the North Carolina Wildlife Resources Commission.

Equipment and facilities are available for undertaking graduate problems in marine and estuarine fisheries.

A variety of positions are open to students holding advanced degrees in animal ecology and wildlife biology. There is particular need for young men with training in parasitology and related subjects. Various State game and fish departments, United States Fish and Wildlife Service, United States Forest Service, United States Soil Conservation Service, United States National Parks Service, and other State and land use departments employ the majority of graduates. Also, an increasing number of teaching positions in these fields are available. There are more job vacancies open to zoologists than can be adequately filled.

Courses for Graduates and Advanced Undergraduates

ZO 501. Ornithology

0-3

Prerequisite: ZO 103

The biology and classification of birds. Field trips for the study and identification of local forms, including trips to Lake Mattamuskeet in February and the coast in May. Individual research projects on nesting populations.

Mr. Quay.

ZO 513. Comparative Animal Physiology

3-0

Prerequisite: ZO 301

The comparative physiology of selected systems. Topics will be chosen for detailed consideration in lectures, collateral reading, and class discussion. Each student will, in addition, prepare a term report. A few topics for study may be determined by the interests of the students and by their needs as may be expressed by the supervisor of their major work.

Mr. Santolucito.

ZO 520. Fishery Science

3-0

Prerequisites: ZO 103 and approval of the instructor

This course is intended as an introduction to the principles and methods of fishery science. Current theories and practices of fish management will be studied. Life history and biology of important game and commercial species. Survey of fishery resources.

Mr. Hassler.

ZO 521. Fishery Science

0-3

Prerequisite: ZO 520

An analysis of fishery research methods and objectives. Detailed studies of the procedures for estimating fish populations, annual reproduction, mortality rates, growth rates, and exploitation rates. The relationship between natural fluctuations in fisheries and environmental factors.

Mr. Hassler.

ZO 522. Animal Ecology

3-0

Prerequisites: ZO 103 and BO 103

The general principles of the inter-relations among animals and between animals and their environments—land, freshwater, marine.

Mr. Quay.

ZO 541. Cold-blooded Vertebrates (Ichthyology)

0-3

Prerequisite: ZO 103

The classification and ecology of selected groups of fishes. Lectures, laboratories, and field trips dealing with the systematic positions, life histories, interrelationships, and distribution of the particular groups of fishes selected in accordance with the needs and interests of the class.

Mr. Hassler.

ZO 542. Cold-blooded Vertebrates (Herpetology)

0-3

Prerequisite: ZO 103

The classification and ecology of selected groups of amphibians and reptiles. Lectures, laboratories, and field trips dealing with the systematic positions, life histories, interrelationships, and distribution of the particular groups of amphibians and reptiles selected in accordance with the needs and interests of the class.

Mr. Hassler.

- ZO 544. Mammalogy** 3-0
Prerequisites: ZO 103, ZO 206, and approval of instructor
The classification, identification, and ecology of the major mammalian groups. Mr. Barkalow.
- ZO 545. Histology** 4-0
Prerequisite: ZO 103
The microscopic anatomy of animal tissues. Mr. Roberts.
- ZO 551, 552. Wildlife Science** 3-3
Prerequisite: ZO 206
The principles of wildlife management and their application are studied in the laboratory and in the field. Mr. Hester.
- ZO 561. Animal Embryology** 0-4
Prerequisite: ZO 103
The study of fundamental principles which apply in the achievement of complex animal structure, including both invertebrate and vertebrate materials. Correlative laboratory study to provide training in the basic disciplines and techniques. This course is intended for advanced students in entomology, animal industry, poultry science, and zoology. Mr. Alliston.
- ZO 571. Special Studies** Credits by Arrangement
Prerequisites: ZO 103 and approval of the instructor
A directed individual investigation of a particular problem in Zoology, accompanied by a review of the pertinent literature. A maximum of three credits allowed toward the bachelor's degree, six toward the master's degree and nine toward the doctorate. Graduate Staff.
- *ZO 581. Parasitology I** 4-0
Prerequisites: ZO 103 and 223
The study of the morphology, biology, and control of the parasitic protozoa and helminths of man, domestic and wild animals. Mr. Harkema.
- **ZO 582. (ENT 582) Medical Entomology** 0-3
Prerequisite: ENT 301 or 312
A study of the morphology, biology and control of the parasitic arthropods of man, domestic and wild animals. Messrs. Farrier and Harkema.

Courses for Graduates Only

- ZO 603. Advanced Parasitology** 0-3
Prerequisites: ZO 581 and 582
The study of the theoretical and practical aspects of parasitism; taxonomy physiology, and immunology of animal parasites. Mr. Harkema.
- ZO 604. (AI 604) Experimental Animal Physiology** 4-0
Prerequisite: ZO 513 or equivalent
A study of the theories and techniques involved in the use of animals in physiological investigation. Messrs. Ulberg, Wise.
- ZO 614. Cell Physiology** 3-0
Prerequisites: ZO 301, and approval of the instructor
A study of those fundamental physiological properties at the cellular level which are common to nearly all organisms. Lectures, discussions, and critical reports (oral and written) to promote acquaintance with general literature and recent advances. Mr. Santolucito.
- ZO 622. Seminar** 1-1
The presentation and defense of current literature papers dealing either with the findings of original research or with fundamental biological concepts. Graduate Staff.

* Offered in the fall 1963.

** Offered in spring 1964.

ZO 627. Zoogeography**3-0**

Prerequisites: ZO 522, and approval of instructor

The geographic distribution of animals, with primary emphasis on land and fresh-water vertebrates.

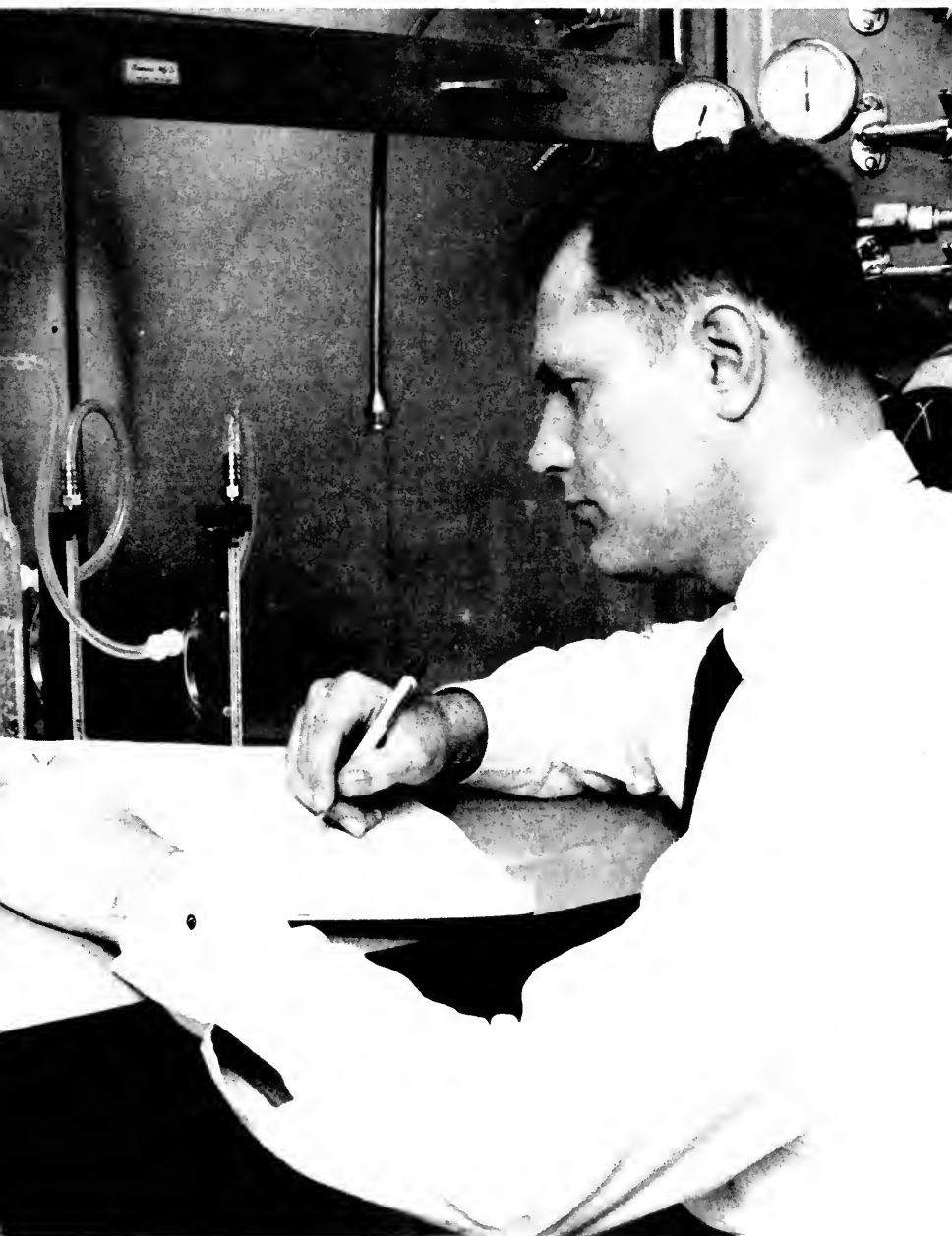
Mr. Quay.

ZO 641. Research in Zoology**Credits by arrangement**

Prerequisites: Twelve semester credits in Zoology, and approval of the instructor

Problems in development, life history, morphology, physiology, ecology, game management, taxonomy, or parasitology. A maximum of six credits is allowed toward the master's degree, but any number toward the doctorate.

Graduate Staff.



TEXTILES—Monomers applied to fibrous polymers in the vapor phase undergo graft polymerizations.



CROP SCIENCE—A suction tube is used to emasculate alfalfa flowers prior to hybridization.



EXPERIMENTAL STATISTICS—The laws of probability are demonstrated by dropping steel balls in a Quincunx.

ENTOMOLOGY—Taxonomic studies of the Aphididae.



OCCUPATIONAL INFORMATION AND GUIDANCE—To improve their counseling procedures, graduate students evaluate tape recordings of each other's counseling conferences.





CERAMIC ENGINEERING—Data is recorded while single crystal sapphires are being examined using a microhardness testing machine.



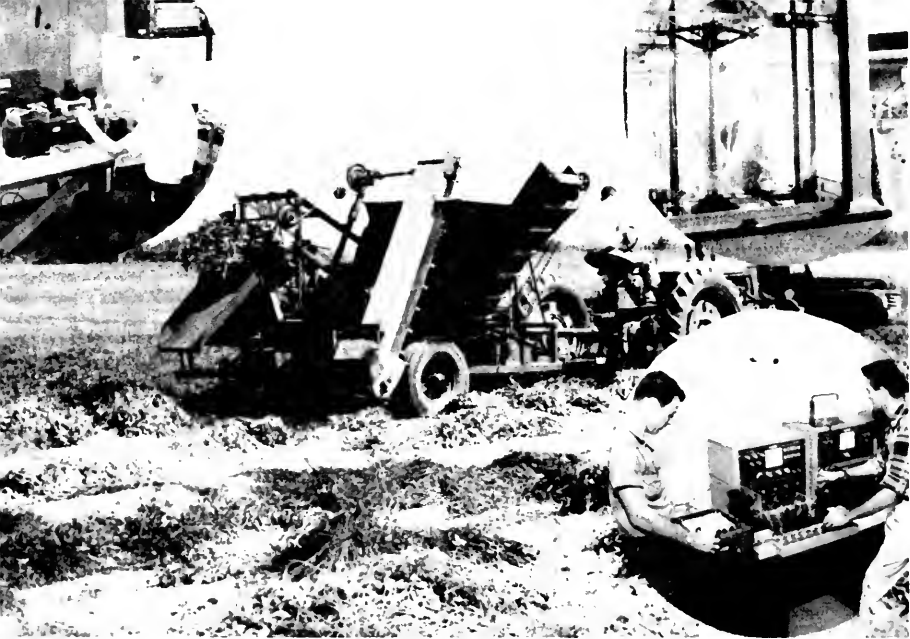
ZOOLOGY—Students study radiographs of experimental fish to determine variation in skeletal structure.



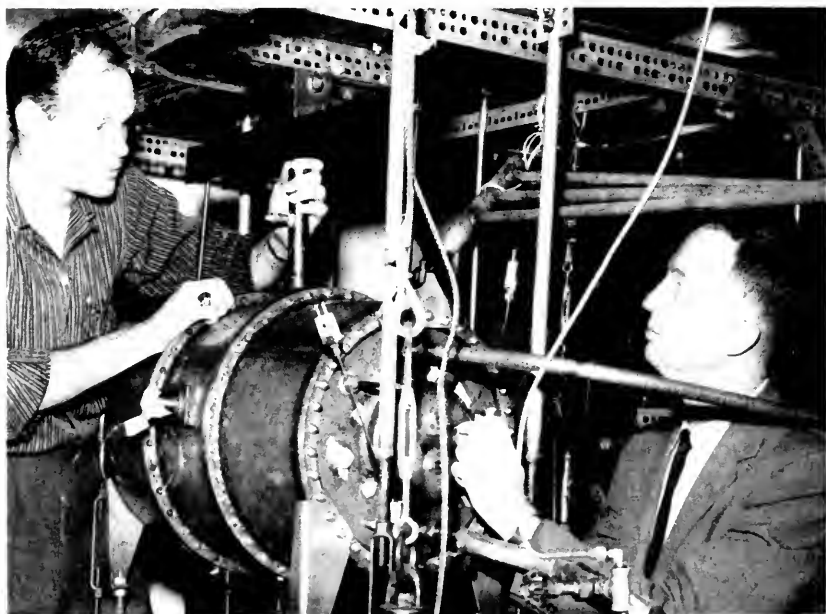
POULTRY SCIENCE—Blood, which will be typed in much the same manner as human blood is typed, is drawn from the wing vein of a chicken.



*PLANT PATH-
OLOGY—State Col-
lege students learn
to diagnose plant
diseases.*



AGRICULTURAL ENGINEERING—Research and development of a once-over peanut harvester: 1) differential fluorescence of plant material, 2) equilibrium moisture content of peanuts, and 3) analog computer for machine analysis.



ENGINEERING MECHANICS—A problem is checked out in the test bearing assembly of apparatus designed for studies of lubrication behavior of liquid metals.

*** GRADUATE FACULTY**
at
NORTH CAROLINA STATE COLLEGE

- Charles Walter Alliston, Assistant Professor of Zoology.
Ph.D., N. C. State College.
- Michael Amein, Assistant Professor of Civil Engineering.
Ph.D., Cornell University.
- Clifton A. Anderson, Professor of Industrial Engineering and Head of Department.
Ph.D., Ohio State University.
- Richard Loree Anderson, Professor of Experimental Statistics.
Ph.D., Iowa State College.
- Roy Nels Anderson, Professor of Education, Head of Department of Occupational Information and Guidance.
Ph.D., Columbia University.
- Jay Lawrence Apple, Associate Professor of Plant Pathology.
Ph.D., N. C. State College.
- Arthur A. Armstrong, Research Associate Professor of Textile Chemistry.
Ph.D., N. C. State College.
- Clarence Monroe Asbill, Jr., Professor of Textile Machine Design and Development.
B.S., Clemson College.
- Leonard William Aurand, Research Professor of Food Science.
Ph.D., Pennsylvania State College.
- William Wyatt Austin, Jr., Professor of Metallurgical Engineering and Head of Department of Mineral Industries.
Ph.D., Vanderbilt University.
- Robert Aycock, Research Professor of Plant Pathology.
Ph.D., N. C. State College.
- Ernest A. Ball, Professor of Botany.
Ph.D., University of California.
- Walter Elmer Ballinger, Associate Professor of Horticultural Science.
Ph.D., Michigan State College.
- Clifford Warren Barber, Professor of Poultry Science.
Ph.D., Cornell University.
- William John Barclay, Professor of Electrical Engineering.
Ph.D., Stanford University.
- Aldos Cortez Barefoot, Jr., Assistant Professor of Wood Products.
Doctor of Forestry, Duke University.
- Frederick Schenck Barkalow, Jr., Professor of Zoology and Head of Department.
Ph.D., University of Michigan.
- Key Lee Barkley, Professor of Psychology and Director of Applied Experimental Psychology Laboratory.
Ph.D., University of North Carolina.
- Elliott Roy Barrick, Professor of Animal Science and Head of Animal Husbandry Section.
Ph.D., Purdue University.
- William Victor Bartholomew, Professor of Soil Science.
Ph.D., Iowa State College.

* Membership in the graduate faculty may be in either of two categories: (1) full status or (2) associate status. Full status permits a faculty member to engage in any and all phases of the graduate programs of the College. Associate members may teach courses at the graduate level and serve as chairmen of master's advisory committees.

- Edward Guy Batte, Professor of Animal Science and Head of Veterinary Section.
D.V.M., Texas A & M.
- Ernest Oscar Beal, Associate Professor of Botany.
Ph.D., State University of Iowa.
- Kenneth Orion Beatty, Jr., Professor of Chemical Engineering.
Ph.D., University of Michigan.
- Burton Floyd Beers, Associate Professor of History and Political Science.
Ph.D., Duke University.
- Norman Robert Bell, Associate Professor of Electrical Engineering.
M.S., Cornell University.
- Thomas A. Bell, Associate Professor of Food Science.
M.S., N. C. State College.
- William Callum Bell, Research Professor of Ceramic Engineering in Engineering Research.
Ph.D., Ohio State University.
- David Maurice Benensen, Associate Professor of Engineering Mechanics.
Ph.D., California Institute of Technology.
- Willard Harrison Bennett, Burlington Professor of Physics.
Ph.D., University of Michigan.
- Ernest Bezold Berry, Assistant Professor of Textiles.
B.S., Clemson College.
- *Richard Hugh Bigelow, Associate Professor of Civil Engineering.
M.S., N. C. State College.
- John William Bishir, Assistant Professor of Mathematics.
Ph.D., N. C. State College.
- Charles Edwin Bishop, William Neal Reynolds Distinguished Professor of Agricultural Economics and Head of Department.
Ph.D., University of Chicago.
- William Joseph Block, Associate Professor of History and Political Science.
Ph.D., University of Illinois.
- William Lowry Blow, Associate Professor of Poultry Science.
Ph.D., N. C. State College.
- T. N. Blumer, Professor of Food Science.
Ph.D., Michigan State College.
- John Francis Bogdan, Professor of Textiles and Director of Processing Research.
B.T.E., Lowell Textile Institute.
- Carey H. Bostian, Professor of Genetics.
Ph.D., University of Pittsburgh.
- Henry Dittimus Bowen, Professor of Agricultural Engineering.
Ph.D., Michigan State College.
- Thomas Glenn Bowery, Research Professor of Chemistry and Entomology.
Ph.D., Rutgers University.
- Charles Raymond Bramer, Professor of Civil Engineering.
E.M., Michigan College of Mining and Technology.
- Bartholomew Brandner Brandt, Professor Emeritus of Zoology.
Ph.D., Duke University.
- Charles H. Brett, Research Associate Professor of Entomology.
Ph.D., Kansas State College.
- Richard Bright, Associate Professor of Chemical Engineering.
M.S., State University of Iowa.
- Charles A. Brim, Associate Professor of Crop Science.
Ph.D., University of Nebraska.

- Henry Seawell Brown, Assistant Professor of Geological Engineering.
Ph.D., University of Illinois.
- Marvin L. Brown, Jr., Professor of History and Political Science.
Ph.D., University of Pennsylvania.
- William Paul Bucher, Assistant Professor of Physics.
Ph.D., University of Virginia.
- Roberts Cozart Bullock, Professor of Mathematics.
Ph.D., University of Chicago.
- Jacob Burlak, Visiting Assistant Professor of Mathematics.
Ph.D., University of Cambridge (England).
- Fred Virgil Cahill, Jr., Professor of History and Political Science and Dean of the School of General Studies.
Ph.D., Yale University.
- George Charles Caldwell, Associate Professor of Mathematics.
Ph.D., University of North Carolina.
- John Tyler Caldwell, Professor of Political Science and Chancellor.
Ph.D., Princeton University.
- Kenneth Stoddard Campbell, Professor of Textile Chemistry.
B.S., Bates College.
- Malcolm Eugene Campbell, Professor of Textiles and Dean of the School of Textiles.
B.S., Clemson College
- William V. Campbell, Research Assistant Professor of Entomology.
Ph.D., N. C. State College.
- Thomas Franklin Cannon, Assistant Professor of Horticultural Science.
Ph.D., Ohio State University.
- George L. Capel, Professor of Agricultural Economics.
Ph.D., University of Florida.
- Robert Gordon Carson, Jr., Professor of Industrial Engineering and Director of Instruction for School of Engineering.
Ph.D., University of Michigan.
- Roy Merwin Carter, Professor of Wood Technology.
M.S., Michigan State College.
- David Marshall Cates, Associate Professor of Textile Chemistry.
Ph.D., Princeton University.
- John Wesley Cell, Professor of Mathematics and Head of Department.
Ph.D., University of Illinois.
- Douglas Scales Chamblee, Professor of Crop Science.
Ph.D., Iowa State College.
- John Montgomery Clarkson, Professor of Mathematics.
Ph.D., Cornell University.
- Albert J. Clawson, Assistant Professor of Animal Science.
Ph.D., Cornell University.
- Carlyle Newton Clayton, Professor of Plant Pathology.
Ph.D., University of Wisconsin.
- Grover Cleveland Cobb, Jr., Assistant Professor of Physics.
Ph.D., University of Virginia.
- Fred Derward Cochran, Professor of Horticulture and Head of Department.
Ph.D., University of California.
- Columbus Clark Cockerham, Professor of Experimental Statistics.
Ph.D., Iowa State College.
- Norval White Conner, Professor of Mechanical Engineering and Director of Department of Engineering Research.
M.S., Iowa State College.
- William Stokes Connor, Adjunct Professor of Experimental Statistics.
Ph.D., University of North Carolina.

- Freeman Waldo Cook, Assistant Professor of Poultry Science.
M.S., N. C. State College.
- John Oliver Cook, Associate Professor of Psychology.
Ph.D., New York University.
- Arthur W. Cooper, Assistant Professor of Botany.
Ph.D., University of Michigan.
- William Earl Cooper, Associate Professor of Plant Pathology.
Ph.D., Louisiana State University.
- Alonzo Freeman Coots, Associate Professor of Chemistry.
Ph.D., Vanderbilt University.
- Will Allen Cope, Research Assistant Professor of Crop Science.
Ph.D., N. C. State College.
- Harold Maxwell Corter, Professor of Psychology, Director of Psychological Clinic.
Ph.D., Pennsylvania State College.
- Arthur James Coutu, Associate Professor of Agricultural Economics.
Ph.D., N. C. State College.
- Gertrude Mary Cox, Professor Emeritus of Experimental Statistics.
M.S., Iowa State College.
- Frank Rankin Craig, Professor of Poultry Science.
D.V.M., University of Georgia.
- Paul Day Cribbins, Associate Professor of Civil Engineering.
Ph.D., Purdue University.
- George A. Cummings, Assistant Professor of Soil Science.
Ph.D., Purdue University.
- William Robert Davis, Assistant Professor of Physics.
Doktor der Naturwiss, University of Hanover, Germany.
- Emmett Urcey Dillard, Associate Professor of Animal Science.
Ph.D., University of Missouri.
- George Osmore Doak, Professor of Chemistry.
Ph.D., University of Wisconsin.
- Wesley Osborne Doggett, Associate Professor of Physics.
Ph.D., University of California.
- Jesse Seymour Doolittle, Professor of Mechanical Engineering.
M.S., Pennsylvania State College.
- Robert Alden Douglas, Associate Professor of Engineering Mechanics.
Ph.D., Purdue University.
- Louis A. Dow, Associate Professor of Economics.
Ph.D., Indiana University.
- Donald W. Drewes, Assistant Professor of Psychology.
Ph.D., Purdue University.
- John Wesley Dudley, Research Assistant Professor of Crop Science.
Ph.D., Iowa State College.
- Arthur Raymond Eckels, Professor of Electrical Engineering.
D. Eng., Yale University.
- Preston William Edsall, Professor of History and Political Science and Head of Department.
Ph.D., Princeton University.
- Gerald H. Elkan, Assistant Professor of Bacteriology.
Ph.D., Virginia Polytechnic Institute.
- Don Edwin Ellis, Professor of Plant Pathology and Head of Department.
Ph.D., University of North Carolina.
- Eric Louis Ellwood, Professor of Wood Products and Head of Department.
Ph.D., Yale University.

- Munir R. El-Saden, Associate Professor of Mechanical Engineering.
Ph.D., University of Michigan.
- Donald Allen Emery, Assistant Professor of Crop Science.
Ph.D., University of Wisconsin.
- John Lincoln Etchells, Professor of Food Science and Botany.
Ph.D., Michigan State College.
- James Brainerd Evans, Professor of Bacteriology.
Ph.D., Cornell University.
- Ralph Eigil Fadum, Professor of Civil Engineering and Dean of the School of Engineering.
S.D., Harvard University.
- Maurice H. Farrier, Research Associate Professor of Entomology and Forestry.
Ph.D., N. C. State College.
- James K. Ferrell, Professor of Chemical Engineering.
Ph.D., N. C. State College.
- Alva Leroy Finkner, Adjunct Professor of Experimental Statistics.
Ph.D., N. C. State College.
- James Walter Fitts, Professor of Soil Science and Head of Department.
Ph.D., Iowa State College.
- Leon David Freedman, Associate Professor of Chemistry.
Ph.D., Johns Hopkins University.
- Raoul M. Freyre, Assistant Professor of Physics.
Ph.D., University of Havana, Cuba.
- Daniel Fromm, Associate Professor of Food Science.
Ph.D., Pennsylvania State University.
- Gene John Galletta, Assistant Professor of Horticultural Science.
Ph.D., University of California.
- Gerald Garb, Assistant Professor of Economics.
Ph.D., University of California.
- Monroe Evans Gardner, Professor of Horticultural Science.
B.S., Virginia Polytechnic Institute.
- Henry Wilburn Garren, Professor of Poultry Science and Head of Department.
Ph.D., University of Maryland.
- Dan Ulrich Gerstel, Research Professor of Crop Science.
Ph.D., University of California.
- Forrest William Getzen, Associate Professor of Chemistry.
Ph.D., Massachusetts Institute of Technology.
- *George Wallace Giles, Professor of Agricultural Engineering.
M.S., University of Missouri.
- Edward Walker Glazener, Professor of Poultry Science and Director of Instruction for School of Agriculture.
Ph.D., University of Maryland.
- Gennaro L. Goglia, Associate Professor of Mechanical Engineering and Graduate Administrator.
Ph.D., University of Michigan.
- Lemuel Goode, Associate Professor of Animal Science.
M.S., University of West Virginia.
- Arnold H. E. Grandage, Professor of Experimental Statistics.
Ph.D., N. C. State College.
- Clifton W. Gray, Assistant Professor of Psychology.
Ph.D., University of Minnesota.

- Walton Carlyle Gregory, William Neal Reynolds Distinguished Professor of Crop Science.
Ph.D., University of Virginia.
- Daniel Swartwood Grosch, Professor of Genetics.
Ph.D., University of Pennsylvania.
- Harry Douglas Gross, Associate Professor of Crop Science.
Ph.D., Iowa State College.
- Elliot Brown Grover, Abel C. Lineberger Professor of Textiles and Head of Department of Textile Technology.
B.S., Massachusetts Institute of Technology.
- George Albert Gullette, Professor of Social Studies and Head of Department.
Ph.D., University of Michigan.
- Frank Edwin Guthrie, Associate Professor of Entomology.
Ph.D., University of Illinois.
- Frank Arlo Haasis, Professor of Plant Pathology.
Ph.D., Cornell University.
- William Cullen Hackler, Associate Professor of Mineral Industries.
Ph.D., N. C. State College.
- Robert John Hader, Professor of Experimental Statistics.
Ph.D., N. C. State College.
- William Jackson Hall, Associate Professor of Statistics.
Ph.D., University of North Carolina.
- Dame Scott Hamby, Burlington Industries Professor of Textiles.
B.S., Alabama Polytechnic Institute.
- Charles Horace Hamilton, Professor of Rural Sociology.
Ph.D., University of North Carolina.
- Durwin M. Hanson, Professor of Industrial Education and Head of Department.
Ph.D., Iowa State University.
- Karl P. Hanson, Professor of Mechanical Engineering.
M.S., University of Michigan.
- Warren Durward Hanson, Professor of Genetics.
Ph.D., Purdue University.
- James W. Hardin, Associate Professor of Botany.
Ph.D., University of Michigan.
- Reinard Harkema, Professor of Zoology.
Ph.D., Duke University.
- Cleon Wallace Harrell, Associate Professor of Economics.
M.A., University of Virginia.
- Walter Joel Harrington, Professor of Mathematics.
Ph.D., Cornell University.
- Clarence Arthur Hart, Research Associate Professor of Forestry.
Ph.D., N. C. State College.
- Lodwick Charles Hartley, Professor of English and Head of Department.
Ph.D., Princeton University.
- Paul Henry Harvey, William Neal Reynolds Distinguished Professor of Crop Science and Head of Department.
Ph.D., Iowa State College.
- Hassan Ahmad Hassan, Professor of Mechanical Engineering.
Ph.D., University of Illinois.
- Francis Jefferson Hassler, Research Professor of Agricultural Engineering and Head of Department.
Ph.D., Michigan State College.
- William Walton Hassler, Associate Professor of Zoology.
Ph.D., University of Tennessee.

- Arthur Courtney Hayes, Associate Professor of Textile Chemistry.
M.S., N. C. State College.
- Frank Lloyd Haynes, Jr., Professor of Horticultural Science.
Ph.D., Cornell University.
- Teddy Theodore Hebert, Professor of Plant Pathology.
Ph.D., N. C. State College.
- William Ray Henry, Associate Professor of Agricultural Economics.
Ph.D., N. C. State College.
- Robert Taylor Herbst, Adjunct Associate Professor of Mathematics.
Ph.D., Duke University.
- Francis Eugene Hester, Assistant Professor of Zoology.
Ph.D., Alabama Polytechnic Institute.
- Charles Horace Hill, Professor of Poultry Science.
Ph.D., Cornell University.
- Thomas I. Hines, Professor of Recreation and Park Administration and
Head of Department.
M.A., University of North Carolina.
- George Burnham Hoadley, Professor of Electrical Engineering and Head of
Department.
D.Sc., Massachusetts Institute of Technology.
- Charles S. Hodges, Jr., Research Assistant Professor of Plant Pathology.
Ph.D., University of Georgia.
- Ernest Hodgson, Assistant Professor of Entomology.
Ph.D., Oregon State University.
- Abraham Holtzman, Associate Professor of History and Political Science.
Ph.D., Harvard University.
- Maurice W. Hoover, Professor of Food Science.
Ph.D., University of Florida.
- John William Horn, Associate Professor of Civil Engineering.
M.S.C.E., Massachusetts Institute of Technology.
- Ivan Hostetler, Professor of Industrial Arts Education and Head of De-
partment.
Ed.D., University of Missouri.
- George Hyatt, Jr., Professor of Animal Science and Associate Director of
Agricultural Extension Service.
Ph.D., University of Wisconsin.
- William A. Jackson, Associate Professor of Soil Science.
Ph.D., N. C. State College.
- Gerald Blaine James, Adjunct Associate Professor of Agricultural Education.
Ed.D., University of Illinois.
- Herman Brooks James, Professor of Agricultural Economics and Dean of
the School of Agriculture.
Ph.D., Duke University.
- John Mitchell Jenkins, Jr., Professor of Horticultural Science.
Ph.D., University of Minnesota.
- Harley Young Jennings, Professor of Textile Research.
Ph.D., University of Michigan.
- Elmer Hubert Johnson, Associate Professor of Sociology and Anthropology.
Ph.D., University of Wisconsin.
- Joseph Clyde Johnson, Associate Professor of Psychology.
Ed.D., Peabody College.
- William Hugh Johnson, Assistant Professor of Agricultural Engineering.
Ph.D., N. C. State College.
- Guy Langston Jones, Professor of Crop Science.
Ph.D., University of Minnesota.

- Ivan Dunlavy Jones, Professor of Food Science.
Ph.D., University of Minnesota.
- Louis Ailman Jones, Associate Professor of Crop Science and Chemistry.
Ph.D., Texas Agricultural and Mechanical College.
- Kenneth Allan Jordan, Assistant Professor of Agricultural Engineering.
Ph.D., Purdue University.
- Charles Howard Kahn, Associate Professor of Architecture.
M.S., Massachusetts Institute of Technology.
- Joseph S. Kahn, Assistant Professor of Botany.
Ph.D., University of Illinois.
- Eugene J. Kamprath, Associate Professor of Soil Science.
Ph.D., N. C. State College.
- Morley Richard Kare, Professor of Poultry Science and Zoology.
Ph.D., Cornell University.
- Constantine Kassimatis, Associate Professor of Mathematics.
Ph.D., Queen's University (Kingston, Canada).
- Therese Marie Kelleher, Assistant Professor of Genetics.
Ph.D., N. C. State College.
- Kenneth Raymond Keller, Professor of Crop Science and Assistant Director in Charge of Tobacco Research.
Ph.D., Iowa State College.
- Joseph Wheeler Kelly, Associate Professor of Poultry Science.
Ph.D., Iowa State College.
- Arthur Kelman, Professor of Plant Pathology and Forest Management.
Ph.D., N. C. State College.
- Richard Adams King, M. G. Mann Professor of Agricultural Economics.
Ph.D., Harvard University.
- James Bryant Kirkland, Professor of Agricultural Education and Dean of the School of Education.
Ph.D., Ohio State University.
- David M. Kline, Research Assistant Professor of Plant Pathology.
Ph.D., University of Wisconsin.
- Glenn Charles Klingman, Professor of Crop Science.
Ph.D., Rutgers University.
- *Richard Bennett Knight, Professor of Mechanical Engineering.
M.S., University of Illinois.
- Ken-ichi Kojima, Associate Professor of Genetics.
Ph.D., N. C. State College.
- John Clement Koop, Associate Professor of Experimental Statistics.
Ph.D., N. C. State College.
- Robert Roy Korfhage, Assistant Professor of Mathematics.
Ph.D., University of Michigan.
- William Wurth Kriegel, Professor in charge of Ceramic Engineering.
Dr. Ing., Technische Hochschule, Hanover, Germany.
- Leaton John Kushman, Associate Professor of Horticultural Science.
M.S., George Washington University.
- John R. Lambert, Associate Professor of Social Studies.
Ph.D., Princeton University.
- Joe Oscar Lammi, Professor of Forestry.
Ph.D., University of California.
- Harold Augustus Lamonds, Professor of Nuclear Engineering and Head of Department.
Ph.D., N. C. State College.

- Forrest Wesley Lancaster, Professor of Physics.
Ph.D., Duke University.
- James Giacomo Lecce, Associate Professor of Animal Science.
Ph.D., University of Pennsylvania.
- James Murray Leatherwood, Assistant Professor of Animal Science.
Ph.D., N. C. State College.
- Thomas Benson Ledbetter, Assistant Professor of Mechanical Engineering.
M.S., N. C. State College.
- Joshua Alexander Lee, Research Assistant Professor of Crop Science.
Ph.D., University of California.
- Richard Shao-Lin Lee, Assistant Professor of Mechanical Engineering.
Ph.D., Harvard University.
- James Edward Legates, William Neal Reynolds Distinguished Professor of Animal Science and Head of Animal Breeding Section.
Ph.D., Iowa State College.
- Samuel George Lehman, Professor Emeritus of Plant Pathology.
Ph.D., Washington University.
- Carlton James Leith, Associate Professor of Mineral Industries.
Ph.D., University of California.
- Jack Levine, Professor of Mathematics.
Ph.D., Princeton University.
- Robert W. Llewellyn, Professor of Industrial Engineering.
M.S., Purdue University.
- Richard Henry Loeppert, Professor of Chemistry.
Ph.D., University of Minnesota.
- George Gilbert Long, Assistant Professor of Chemistry.
Ph.D., University of Florida.
- Roy Lee Lovvorn, Professor of Crop Science and Director of Research in the School of Agriculture.
Ph.D., University of Wisconsin.
- Morton Lowengrub, Assistant Professor of Mathematics.
Ph.D., Duke University.
- George Blanchard Lucas, Research Associate Professor of Plant Pathology.
Ph.D., Louisiana State University.
- Henry Laurence Lucas, Jr., William Neal Reynolds Distinguished Professor of Experimental Statistics.
Ph.D., Cornell University.
- James Fulton Lutz, Professor of Soil Science.
Ph.D., University of Missouri.
- Joseph Thomas Lynn, Associate Professor of Physics and Graduate Administrator.
M.S., Ohio State University.
- Glenn C. McCann, Associate Professor of Rural Sociology.
Ph.D., Washington State College.
- Charles B. McCants, Associate Professor of Soil Science.
Ph.D., Iowa State College.
- Robert E. McCollum, Research Assistant Professor of Soil Science.
Ph.D., University of Illinois.
- Clarence Leslie McCombs, Associate Professor of Horticultural Science.
Ph.D., Ohio State University.
- Ralph Joseph McCracken, Associate Professor of Soil Science.
Ph.D., Iowa State College.

- Charles Russell McCullough, Professor of Civil Engineering.
M.S., Purdue University.
- Patrick Hill McDonald, Professor of Engineering Mechanics and Head of Department.
Ph.D., Northwestern University.
- William McGehee, Visiting Professor of Psychology.
Ph.D., Peabody College.
- John Joseph McNeill, Assistant Professor of Animal Science.
Ph.D., University of Maryland.
- Francis Edward McVay, Associate Professor of Experimental Statistics.
Ph.D., University of North Carolina.
- James Gray Maddox, Professor of Agricultural Economics.
Ph.D., Harvard University.
- T. Ewald Maki, Carl Alwin Schenck Professor of Forest Management.
Ph.D., University of Minnesota.
- Carroll Lamb Mann, Jr., Professor of Civil Engineering.
C.E., Princeton University.
- Thurston Jefferson Mann, Professor of Crop Science.
Ph.D., Cornell University.
- Edward George Manning, Associate Professor of Electrical Engineering.
M.S., N. C. State College.
- David Boyd Marsland, Assistant Professor of Chemical Engineering.
Ph.D., Cornell University.
- David Hamilton Martin, Assistant Professor of Physics.
M.S., University of Wisconsin.
- David Dickenson Mason, Professor of Experimental Statistics.
Ph.D., N. C. State College.
- Gennard Matrone, Research Professor of Animal Science.
Ph.D., N. C. State College.
- Dale Frederick Matzinger, Associate Professor of Genetics.
Ph.D., Iowa State College.
- Jack R. Mauney, Research Assistant Professor of Crop Science.
Ph.D., University of Wisconsin.
- Selz Cabot Mayo, Professor of Rural Sociology and Head of Department.
Ph.D., University of North Carolina.
- Jefferson Sullivan Meares, Professor of Physics.
M.S., N. C. State College.
- Arthur Clayton Menius, Jr., Professor of Physics and Dean of the School of Physical Sciences and Applied Mathematics.
Ph.D., University of North Carolina.
- Lawrence Eugene Mettler, Assistant Professor of Genetics.
Ph.D., University of Texas.
- Gordon Kennedy Middleton, Professor Emeritus of Crop Science.
Ph.D., Cornell University.
- Conrad Henry Miller, Assistant Professor of Horticultural Science.
Ph.D., Michigan State University.
- Grover Cleveland Miller, Assistant Professor of Zoology.
Ph.D., Louisiana State University.
- Howard G. Miller, Professor of Psychology and Head of Department.
Ph.D., Pennsylvania State University.
- Philip Arthur Miller, Professor of Crop Science.
Ph.D., Iowa State.
- William Dykstra Miller, Associate Professor of Forestry.
Ph.D., Yale University.

- Walter Joseph Mistic, Associate Professor of Entomology.
Ph.D., A & M College of Texas.
- Adolphus Mitchell, Professor of Engineering Mechanics.
M.S., University of North Carolina.
- Theodore Bertis Mitchell, Professor Emeritus of Entomology.
D.S., Harvard University.
- Richard Douglas Mochrie, Associate Professor of Animal Science.
Ph.D., N. C. State College.
- Robert Harry Moll, Assistant Professor of Genetics.
Ph.D., N. C. State College.
- *Robert James Monroe, Professor of Experimental Statistics.
Ph.D., N. C. State College.
- Elmer Leon Moore, Professor of Plant Pathology.
Ph.D., University of Wisconsin.
- Robert Parker Moore, Professor of Crop Science.
Ph.D., Ohio State University.
- Charles G. Morehead, Associate Professor of Occupational Information and Guidance.
Ed.D., University of Kansas.
- Donald Edwin Moreland, Associate Professor of Crop Science.
Ph.D., N. C. State College.
- Carey Gardner Mumford, Professor of Mathematics and Assistant to Dean of the School of Physical Sciences and Applied Mathematics.
Ph.D., Duke University.
- W. Ray Murley, Professor of Animal Science.
Ph.D., Iowa State College.
- Raymond LeRoy Murray, Burlington Professor of Physics and Head of Department.
Ph.D., University of Tennessee.
- Peter Musen, Professor of Mathematics.
Ph.D., University of Belgrade (Yugoslavia).
- Howard Movess Nahikian, Professor of Mathematics.
Ph.D., University of North Carolina.
- Richard Robert Nelson, Associate Professor of Plant Pathology.
Ph.D., University of Minnesota.
- Herbert H. Neunzig, Assistant Professor of Entomology.
Ph.D., Cornell University.
- Slater Edmund Newman, Associate Professor of Psychology.
Ph.D., Northwestern University.
- Lowell Wendell Nielsen, Professor of Plant Pathology.
Ph.D., Cornell University.
- Stuart Noblin, Professor of History and Political Science.
Ph.D., University of North Carolina.
- Charles Joseph Nusbaum, William Neal Reynolds Distinguished Professor of Plant Pathology.
Ph.D., University of Wisconsin.
- Bernard Martin Olsen, Associate Professor of Economics.
Ph.D., University of Chicago.
- Guy Owen, Jr., Associate Professor of English.
Ph.D., University of North Carolina.
- Hayne Palmour, III, Associate Professor of Mineral Industries.
Ph.D., N. C. State College.
- Hubert Vern Park, Professor of Mathematics.
Ph.D., University of North Carolina.

- Thomas H. Park, Assistant Professor of Economics.
A.B., Vanderbilt University.
- John Mason Parker, III, Professor in charge of Geological Engineering.
Ph.D., Cornell University.
- Thomas Oliver Perry, Associate Professor of Forestry.
Ph.D., Harvard University.
- Roger Gene Petersen, Associate Professor of Experimental Statistics.
Ph.D., N. C. State College.
- Walter John Peterson, William Neal Reynolds Distinguished Professor of Chemistry and Dean of the Graduate School.
Ph.D., University of Iowa.
- Wilbur Carroll Peterson, Associate Professor of Electrical Engineering.
Ph.D., Northwestern University.
- Lyle L. Phillips, Associate Professor of Crop Science.
Ph.D., University of Washington.
- Walter Henry Pierce, Professor of Agricultural Economics.
Ph.D., University of Minnesota.
- Richard Coleman Pinkerton, Associate Professor of Chemistry.
Ph.D., Iowa State University.
- Robert McLean Pinkerton, Professor of Aeronautical Engineering.
B.Sc., Bradley University.
- George Waverly Poland, Professor of Modern Languages and Head of Department.
Ph.D., University of North Carolina.
- Daniel Townsend Pope, Associate Professor of Horticultural Science.
Ph.D., Cornell University.
- Joseph Alexander Porter, Jr., Associate Professor of Textiles.
M.S., N. C. State College.
- I. D. Porterfield, Professor of Animal Science and Head of Department.
Ph.D., University of Minnesota.
- Nathaniel T. Powell, Assistant Professor of Plant Pathology.
Ph.D., N. C. State College.
- Richard Joseph Preston, Professor of Forestry and Dean of the School of Forestry.
Ph.D., University of Michigan.
- Charles Harry Proctor, Associate Professor of Experimental Statistics.
Ph.D., Michigan State University.
- Thomas Lavalley Quay, Professor of Zoology.
Ph.D., N. C. State College.
- Robert Lamar Rabb, Associate Professor of Entomology.
Ph.D., N. C. State College.
- Harold Arch Ramsey, Associate Professor of Animal Science.
Ph.D., N. C. State College.
- John Oren Rawlings, Assistant Professor of Statistics.
Ph.D., N. C. State College.
- Horace D. Rawls, Associate Professor of Sociology and Anthropology.
M.S., N. C. State College.
- Preston Harding Reid, Associate Professor of Soil Science.
Ph.D., N. C. State College.
- Willis Alton Reid, Professor of Chemistry.
Ph.D., University of Wisconsin.
- Frances M. Richardson, Research Associate Professor of Engineering Research.
M.S., University of Cincinnati.

- Jackson Ashcraft Rigney, Professor of Experimental Statistics and Head of Department.
M.S., Iowa State College.
- William Milner Roberts, Professor of Food Science and Head of Department.
Ph.D., University of Minnesota.
- Cowin Cook Robinson, Professor of Chemistry.
Ph.D., University of Wisconsin.
- Harold Frank Robinson, Professor of Genetics and Head of Department.
Ph.D., Nebraska University.
- Odis Wayne Robison, Assistant Professor of Animal Science.
Ph.D., University of Wisconsin.
- John Paul Ross, Associate Professor of Plant Pathology.
Ph.D., Cornell University.
- Paul James Rust, Associate Professor of Psychology and English.
Ph.D., University of Washington.
- Henry Ames Rutherford, Professor of Textile Chemistry and Head of Department.
M.A., George Washington University.
- John A. Santolucito, Associate Professor of Zoology.
Ph.D., University of California.
- Joseph Neal Sasser, Associate Professor of Plant Pathology.
Ph.D., University of Maryland.
- Clarence Cayce Scarborough, Professor of Agricultural Education and Head of Department.
Ed.D., University of Illinois.
- George Edward Schafer, Professor of Electrical Engineering.
Ph.D., University of Colorado.
- Edward Martin Schoenborn, Jr., Professor of Chemical Engineering and Head of Department.
Ph.D., Ohio State University.
- Robert Johnson Schramm, Jr., Assistant Professor of Horticultural Science.
Ph.D., Duke University.
- *Herbert Temple Scofield, Professor of Botany and Head of Department.
Ph.D., Cornell University.
- James Arthur Seagraves, Associate Professor of Agricultural Economics.
Ph.D., Iowa State College.
- John Frank Seely, Associate Professor of Chemical Engineering.
M.S., North Carolina State College.
- Heinz Seltmann, Assistant Professor of Botany.
Ph.D., University of Chicago.
- Luther Shaw, Associate Professor of Crop Science.
Ph.D., University of Wisconsin.
- Ching S. Shen, Assistant Professor of Economics.
Ph.D., University of North Carolina.
- Francis Webber Sherwood, Professor Emeritus of Animal Science.
Ph.D., Cornell University.
- Robert T. Sherwood, Research Assistant Professor of Plant Pathology.
Ph.D., University of Wisconsin.
- William Edward Shinn, Chester H. Roth, Professor of Knitting and Head of Knitting Department, School of Textiles.
M.S., N. C. State College.
- John William Shirley, Professor of English and Dean of the Faculty.
Ph.D., University of Iowa.

- Darrell Rhea Shreve, Associate Professor of Mathematics, and Director of Computing Laboratory.
Ph.D., University of Illinois.
- Richard Lee Simmons, Assistant Professor of Agricultural Economics.
Ph.D., University of California.
- Edward Carroll Sisler, Assistant Professor of Chemistry and Crop Science.
Ph.D., N. C. State College.
- Norman Clifford Small, Associate Professor of Engineering Mechanics.
Ph.D., Brown University.
- Charles Smallwood, Jr., Professor of Civil Engineering and Graduate Administrator.
M.S., Harvard University.
- William Wesley Garry Smart, Jr., Research Associate Professor of Animal Science and Experimental Statistics.
Ph.D., North Carolina State College.
- Frederick Otto Smetana, Associate Professor of Mechanical Engineering.
Ph.D., University of Southern California.
- Benjamin Warfield Smith, Professor of Genetics.
Ph.D., University of Wisconsin.
- Clyde Fuhriman Smith, Professor of Entomology and Head of Department.
Ph.D., Ohio State University.
- Frank Houston Smith, Research Professor of Animal Science.
M.S., N. C. State College.
- Rufus Hummer Snyder, Professor of Physics.
Ph.D., Ohio State University.
- James Maurice Spain, Associate Professor of Soil Science.
Ph.D., Purdue University.
- Marvin Luther Speck, Reynolds Professor of Food Science.
Ph.D., Cornell University.
- Herbert Elvin Speece, Associate Professor of Mathematics and Education.
Ph.D., University of North Carolina.
- William Eldon Splinter, Professor of Agricultural Engineering.
Ph.D., Michigan State University.
- Hans Heinrich Anton Stadelmaier, Research Professor of Mineral Industries.
Dr. rer. nat., Technische Hochschule, Stuttgart, Germany.
- Alfred J. Stamm, Research Professor of Wood Technology.
Ph.D., University of Wisconsin.
- Robert George Douglas Steel, Professor of Experimental Statistics.
Ph.D., Iowa State College.
- Anthony Paul Stemberger, Associate Professor of Agricultural Economics.
Ph.D., N. C. State College.
- William A. Stephen, Assistant Professor of Entomology.
M.A., University of Toronto, Canada.
- Stanley G. Stephens, William Neal Reynolds Distinguished Professor of Genetics.
Ph.D., Edinburgh University, Scotland.
- William Damon Stevenson, Jr., Professor of Electrical Engineering and Graduate Administrator.
M.S., University of Michigan.
- Hamilton Arlo Stewart, Professor of Animal Science and Assistant Director of Research in the School of Agriculture.
Ph.D., University of Minnesota.
- Robert Franklin Stoops, Research Professor of Ceramic Engineering.
Ph.D., Ohio State University.

- Raimond Aldrich Struble, Professor of Mathematics.
Ph.D., University of Notre Dame.
- William Clifton Stuckey, Jr., Associate Professor of Textiles.
M.S., N. C. State College.
- Charles Wilson Suggs, Assistant Professor of Agricultural Engineering.
Ph.D., N. C. State College.
- Joseph Gwyn Sutherland, U.S.D.A. Agricultural Economist.
Ph.D., N. C. State College.
- Paul Porter Sutton, Professor of Chemistry.
Ph.D., Johns Hopkins University.
- Ralph Clay Swann, Head and Professor of Chemistry.
Ph.D., Massachusetts Institute of Technology.
- Ernst W. Swanson, Professor of Economics and Head of Department.
Ph.D., University of Chicago.
- Donald Loraine Thompson, Associate Professor of Crop Science.
Ph.D., Iowa State College.
- David Harry Timothy, Associate Professor of Crop Science.
Ph.D., University of Minnesota.
- George Stanford Tolley, Professor of Agricultural Economics.
Ph.D., University of Chicago.
- John W. Tomlin, Assistant Professor of Sociology and Anthropology.
Ph.D., University of Maryland.
- William Douglas Toussaint, Professor of Agricultural Economics.
Ph.D., Iowa State College.
- Samuel B. Tove, Research Professor of Animal Science and Chemistry.
Ph.D., University of Wisconsin.
- Anastasios Christos Triantaphyllou, Assistant Geneticist.
Ph.D., N. C. State College.
- Hedwig Hirschmann Triantaphyllou, Associate Professor of Plant Pathology.
Ph.D., University of Erlangen, Germany.
- James Richard Troyer, Associate Professor of Botany.
Ph.D., Columbia University.
- Robert Wesley Truitt, Professor of Mechanical Engineering and Head of Department.
Ph.D., Virginia Polytechnic Institute.
- Lester Curtis Ulberg, Professor of Animal Science.
Ph.D., University of Wisconsin.
- Newton Underwood, Professor of Physics.
Ph.D., Brown University.
- Robert Phillip Upchurch, Research Associate Professor of Crop Science.
Ph.D., University of California.
- Mehmet Ensar Uyanik, Professor of Civil Engineering.
Ph.D., University of Illinois.
- Jan van Schilfgaarde, Research Associate Professor of Agricultural Engineering.
Ph.D., Iowa State College.
- Hubertus Robert van der Vaart, Associate Professor of Experimental Statistics.
Ph.D., University of Leiden, Netherlands.
- Richard J. Volk, Associate Professor of Soil Science.
Ph.D., N. C. State College.
- James Hatton Wahab, Professor of Mathematics.
Ph.D., University of North Carolina.

- Thomas Dudley Wallace, Assistant Professor of Agricultural Economics and Experimental Statistics.
M.S., Oklahoma State University.
- Arthur W. Waltner, Professor of Physics.
Ph.D., University of North Carolina.
- Daniel Shou-ling Wang, Associate Professor of Engineering Mechanics.
Ph.D., University of Illinois.
- Frederick Gail Warren, Associate Professor of Food Science.
Ph.D., Pennsylvania State College.
- Geoffrey Stuart Watson, Adjunct Professor of Experimental Statistics.
Ph.D., N. C. State College.
- David S. Weaver, Professor Emeritus of Agricultural Engineering and Assistant to the Dean of the School of Agriculture.
M.S., N. C. State College.
- Sterling B. Weed, Associate Professor of Soil Science.
Ph.D., N. C. State College.
- Bertram W. Wells, Professor Emeritus of Botany.
Ph.D., University of Chicago.
- Joseph Arthur Weybrew, William Neal Reynolds Distinguished Professor of Crop Science and Chemistry.
Ph.D., University of Wisconsin.
- Raymond Cyrus White, Associate Professor of Chemistry.
Ph.D., West Virginia University.
- John Kerr Whitfield, Associate Professor of Mechanical Engineering.
M.S., N. C. State College.
- Larry Alston Whitford, Professor of Botany.
Ph.D., Ohio State University.
- Rudolph Willard, Visiting Lecturer in Industrial Engineering.
Ph.B., Yale University.
- James Claude Williamson, Jr., Associate Professor of Agricultural Economics.
M.S., N. C. State College.
- Nash Nicks Winstead, Professor of Plant Pathology.
Ph.D., University of Wisconsin.
- Sanford Richard Winston, Professor of Sociology and Head of Department.
Ph.D., University of Minnesota.
- Lowell Sheridan Winton, Professor of Mathematics.
Ph.D., Duke University.
- George Herman Wise, William Neal Reynolds Distinguished Professor of Animal Science, Head of Animal Nutrition Section.
Ph.D., University of Minnesota.
- Milton B. Wise, Associate Professor of Animal Science.
Ph.D., Cornell University.
- Willie Garland Woltz, Professor of Soil Science.
Ph.D., Cornell University.
- James Woodburn, Professor of Mechanical Engineering.
Dr. Engr., Johns Hopkins University.
- William Walton Woodhouse, Jr., Professor of Soil Science.
Ph.D., Cornell University.
- James T. Yen, Assistant Professor of Mechanical Engineering.
Ph.D., University of Minnesota.
- David Allan Young, Jr., Professor of Entomology.
Ph.D., University of Kansas.
- James N. Young, Assistant Professor of Rural Sociology.
Ph.D., University of Kentucky.

- Talmage Brian Young, Associate Professor of Industrial Arts Education.
Ph.D., University of Florida.
- Sanford Eugene Younts, Associate Professor of Soil Science.
Ph.D., Cornell University.
- Paul Z. T. Zia, Associate Professor of Civil Engineering.
Ph.D., University of Florida.
- Bruce J. Zobel, Professor of Forestry.
Ph.D., University of California.
- Carl Frank Zorowski, Associate Professor of Mechanical Engineering.
Ph.D., Carnegie Institute of Technology.

THE COLLEGE CALENDAR*SUMMER SESSIONS****1962****First Session**

June 12	Tues.	Registration. Late registration fee of \$5.00 payable by all who register after June 12.
June 13	Wed.	First day of classes.
June 18	Mon.	Last day for registration. Last day to withdraw with refund and last day to drop any course with refund.
June 22	Fri.	Last day for dropping courses without failure and last day to withdraw without failure.
June 28	Thurs.	<i>Last day for accepting theses for candidates for the master's and doctoral degrees in July.</i>
July 3	Tues.	<i>Last day for taking qualifying examinations for students expecting to receive doctorate in January.</i>
July 4	Wed.	Holiday
July 12	Thurs.	<i>Last day for taking final oral examination for candidates for the master's and doctoral degrees in July.</i>
July 18	Wed.	Last day of classes.
July 19	Thurs.	Final examinations.

Second Session

July 20	Fri.	Registration. Late fee of \$5.00 payable by all who register after July 20.
July 23	Mon.	First day of classes.
July 27	Fri.	Last day for registration. Last day to withdraw with refund and last day to drop any course with refund.
August 1	Wed.	Last day for dropping courses without failure and last day to withdraw without failure.
August 3	Fri.	<i>Last day for accepting theses for candidates for the master's and doctoral degrees in August.</i>
August 17	Fri.	<i>Last day for taking final oral examination for candidates for the master's and doctoral degree in August.</i>
August 23	Thurs.	Last day of classes.
August 24	Fri.	Final examinations.

FALL SEMESTER**1962**

September 10	Mon.	General faculty meeting.
September 14	Fri.	Registration. Late registration fee of \$5.00 payable by all who register after September 14. Classes begin at 8:00 a.m.
September 17	Mon.	
September 21	Fri.	Last day for registration. Last day for refund less \$5.00 registration fee. <i>Last day for filing application for admission to candidacy for students expecting to complete requirements for the master's degree in January.</i>

* Application for admission to the Graduate School, accompanied by full credentials in the form of transcripts of academic records, should be filed in the office of the Graduate Dean at least thirty days in advance of the semester in which admission is sought.

September 28	Fri.	Last day to add a course.
October 5	Fri.	Last day to drop a course without failure. <i>Last day for taking qualifying examinations for students expecting to receive doctorate in June.</i>
November 5	Mon.	Meeting of the Graduate Executive Council of the Consolidated University.
November 10	Sat.	Mid-term reports.
November 21	Wed.	Thanksgiving holidays begin at 1:00 p.m.
November 26	Mon.	Classwork resumes at 8:00 a.m.
November 27	Tues.	Last day to withdraw from school without failures.
December 17	Mon.	<i>Last day for accepting theses for candidates for the Ph.D. degree in January.</i>
December 19	Wed.	Christmas holidays begin at 6:00 p.m.
December 31	Mon.	<i>Last day for accepting theses for candidates for the master's degree in January.</i>
January 3, 1963	Thurs.	Classwork resumes at 8:00 a.m.
January 11	Fri.	<i>Last day for taking final oral examinations for candidates for the master's degree in January.</i>
January 16	Wed.	Last day of classes.
January 18	Fri.	<i>Last day for taking final oral examinations for candidates for the Ph.D. degree in January.</i>
January 18-25	Fri.-Fri.	Final examinations.
January 21	Mon.	Meeting of the Graduate Executive Council of the Consolidated University.

SPRING SEMESTER 1963

February 1	Fri.	Registration. Late registration fee of \$5.00 payable by all who register after February 1.
February 4	Mon.	Classes begin at 8:00 a.m.
February 8	Fri.	Last day to register. Last day for refund less \$5.00 registration fee. <i>Last day for filing application for admission to candidacy for students expecting to complete requirements for the master's degree in June.</i>
February 15	Fri.	Last day to add a course.
February 22	Fri.	Last day to drop a course without failure. <i>Last day for taking qualifying examinations for students expecting to receive doctorate in August.</i>
March 23	Sat.	Mid-term reports.
April 1	Mon.	Meeting of the Graduate Executive Council of the Consolidated University.
April 5	Fri.	Last day for withdrawing from school without failures.
April 11	Thurs.	Easter holidays begin at 12:00 noon.
April 17	Wed.	Classwork resumes at 8:00 a.m.
April 22	Mon.	<i>Last day for accepting theses for candidates for the Ph.D. degree in June.</i>
May 6	Mon.	<i>Last day for accepting theses for candidates for the master's degree in June.</i>
May 17	Fri.	<i>Last day for taking final oral examination for candidates for the master's degree in June.</i>

May 22	Wed.	Last day of classes.
May 24	Fri.	<i>Last day for taking final oral examination for candidates for the Ph.D. degree in June.</i>
May 24-31	Fri.-Fri.	Final examinations.
June 1	Sat.	Commencement.

SUMMER SESSIONS 1963

First Session

June 11	Tues.	Registration. Late registration fee of \$5.00 payable by all registering after June 11.
June 12	Wed.	First day of classes.
June 17	Mon.	Last day for registration. Last day to withdraw with refund and last day to drop any course with refund.
June 21	Fri.	Last day to drop courses without failure and last day to withdraw without failure.
June 28	Fri.	<i>Last day for accepting theses for candidates for master's and doctoral degrees in July.</i>
July 4-5	Thurs.-Fri.	Holidays.
July 12	Fri.	<i>Last day for taking final oral examinations for candidates for the master's and doctoral degrees in July.</i>
July 18	Thurs.	Last day of classes.
July 19	Fri.	Final examinations.

Second Session

July 22	Mon.	Registration. Late registration fee of \$5.00 payable by all registering after July 22.
July 23	Tues.	First day of classes.
July 29	Mon.	Last day for registration. Last day to withdraw with refund and last day to drop any course with refund.
August 2	Fri.	Last day to drop courses without failure and last day to withdraw without failure. <i>Last day for accepting theses for candidates for the master's and doctoral degrees in August.</i>
August 16	Fri.	<i>Last day for taking final oral examination for candidates for the master's and doctoral degrees in August.</i>
August 23	Fri.	Last day of classes.
August 24	Sat.	Final examinations.

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